

State of California
California Environmental Protection Agency

AIR RESOURCES BOARD

**REVISED
PRELIMINARY STAFF ASSESSMENT**

**MARCH 29 WORKSHOP
ZEV 2000 BIENNIAL REVIEW**

This document has been reviewed by the staff of the California Air Resources Board. Publication does not signify that the contents necessarily reflect the views and policies of the Air Resources Board.

EXECUTIVE SUMMARY

The Air Resources Board's Zero Emission Vehicle (ZEV) program was originally adopted in 1990, as part of the first Low-Emission Vehicle regulations. The ZEV program is an integral part of California's mobile source control efforts, and is intended to create a market for advanced technologies that will secure maximum air quality benefits for California now and into the future.

Continued reliance on today's technology will not allow California to reach its health-based air quality goals. In ARB's vision of the future, therefore, the vehicle fleet will produce zero tailpipe emissions, and will use fuels with minimal "fuel cycle" emissions (emissions that occur due to vehicle refueling and the related production or transportation of fuel). Among the auto manufacturers, there is a general consensus that global customer demands will reward companies that can meet society's transportation needs while eliminating harmful environmental impacts. Thus, although there may be disagreements over the pace of change and the path to be followed, the ultimate goal is not in question.

Pure zero-emission vehicles hold distinct air quality advantages over technologies that use a conventional fuel such as gasoline in a combustion engine. Vehicles with combustion engines inevitably exhibit deterioration that results in increased emission levels as the vehicle ages. They are also subject to becoming gross polluters if critical emission control systems fail. High volatility liquid fuels such as gasoline are responsible for significant fuel cycle emissions. For all of these reasons, vehicles with no potential to produce emissions are the "gold standard" of even the cleanest, most advanced new technologies.

When the ZEV requirement was adopted in 1990, low- and zero-emission vehicle technology was in a very early stage of development. The Board acknowledged that many issues would need to be addressed throughout the program's implementation. Thus the Board directed staff to provide an update on the ZEV program on a biennial basis, in order to provide a context for the necessary policy discussion and deliberation. The next biennial review of the ZEV program is scheduled for September 2000.

In preparing for the Board's upcoming Biennial Review, the goal of the staff is to provide a thorough, accurate portrayal of the current status of ZEV technology and the prospects for improvement in the near- and long-term. Extensive staff work is underway in a variety of areas. This document outlines the information developed to date, and describes other efforts underway that will provide additional information as the review proceeds. In particular, the battery technology, cost, emission benefit, and EV market sections of this document will be significantly expanded and revised when ongoing work is completed. Thus a complete assessment of the full range of relevant issues will be first presented in the next iteration of this document, in time for a workshop in May.

The purpose of this document is to put forth technical information for public review and comment, develop a framework and context for consideration of the relevant issues, and provide an opportunity for interested parties to point out errors, omissions, or other problems in the factual basis that will be made available to the Board. Comments are welcome on all aspects of this material.

Manufacturer Status

The ZEV requirement applies to large and intermediate volume manufacturers. Beginning in model year (MY) 2003, at least 10 percent of the passenger cars and light duty trucks produced and delivered for sale in California by large and intermediate volume manufacturers must be ZEVs. An intermediate volume manufacturer may meet this ZEV requirement entirely with partial ZEV allowance vehicles. A large volume manufacturer must meet at least 40 percent of its ZEV requirement with pure ZEVs or full ZEV allowance vehicles. Large volume manufacturers may, at their option, meet the remaining 60 percent of their ZEV requirement with partial ZEV allowance vehicles.

Because MY (model year) 2003 is quickly approaching and planning for MY 2003 production has already begun, ARB staff has attempted to establish each manufacturer's volume classification and, thus, each manufacturer's ZEV requirement. Based on current production and sales data, ARB staff expects the small volume manufacturers in MY 2003 to be Porsche, Saab, GFI, Ferrari, Dae Woo Motor Company, Rolls Royce, Suzuki, Lamborghini and Lotus. Based on the same data, ARB staff expects the intermediate volume manufacturers in MY 2003 to be BMW, Subaru (Fuji), Hyundai, Isuzu, Jaguar, Kia, Mazda, Mitsubishi, Rover, Volkswagen and Volvo. ARB staff expects the large manufacturers in MY 2003 to be DaimlerChrysler, Ford, GM, Honda, Nissan and Toyota.

In recent years there have been many new multi-manufacturer arrangements, which have made it difficult to delineate individual companies. To clarify the ZEV-related emission compliance liabilities of companies in multi-manufacturer arrangements, ARB staff will hold a workshop on March 30, 2000.

In rough terms, each one percent of California light-duty vehicle sales equals about ten thousand vehicles per year. The calculation of the actual number of vehicles needed to meet the ZEV requirement in any given year, however, is considerably more complex. To provide a context for the Board's evaluation of the ZEV program, staff have developed a "base case" estimate of the number of ZEVs that the major manufacturers must produce in 2003 in order to satisfy a four percent ZEV requirement. Due to trade secret considerations, this estimate does not rely on any confidential information provided in the manufacturer product plans. Assuming that the vehicles used to meet the requirement have the same range as the vehicles available today, staff estimates that roughly 22,000 zero emission vehicles would need to be produced in 2003. This corresponds to about 2.3 percent of the passenger car and light duty truck

production of the affected manufacturers. It must be noted, however, that actual 2003 ZEV production may vary significantly from this number.

All manufacturers have indicated that they have the technical capability to produce the quantity of vehicles needed to meet their 2003 obligation. The manufacturers uniformly argued, however, that the cost of these vehicles remains high, and foreseeable battery technology will result in limitations on vehicle range. Thus in their view it will be difficult to develop a self-sustaining mass market for battery electric vehicles at this time.

Staff notes that technical advances are steadily reducing the cost premium associated with ZEVs and that increased production volume will bring about further reductions. Because the status of battery technology is central to any discussion of cost and feasibility, such issues will be addressed more completely in the next iteration of this document, following the receipt of a report from a panel of outside experts that is reviewing battery cost and performance.

Compliance with the Memoranda of Agreement

In 1996, the Executive Officer of the Air Resources Board and all major auto manufacturers signed Memoranda of Agreement (MOAs). The MOAs are intended to ensure the successful introduction of zero emission vehicles into the marketplace. They include numerous binding commitments from each of the auto manufacturers as well as from ARB. Staff concludes that the manufacturers and the ARB have met their current commitments in the MOAs. As part of the state's efforts, the ARB and the Department of General Services have undertaken a number of activities designed to facilitate leasing of ZEVs. Such efforts include the EV Loan Program, the EV Sacramento Program, the EV Rental Demonstration Program, the EV Long Term Placement Program, and outreach by the Office of Fleet Administration.

Vehicle Technology Assessment

In June 1999, ARB began meeting with auto manufacturers to discuss their obligations and plans for meeting the ZEV requirement in MY 2003. In December 1999 and February 2000, ARB staff visited all the large volume manufacturers in Japan and in the United States to examine, first hand, the progress each manufacturer is making in preparing to meet the ZEV requirement.

From the inception of the ZEV program, the battery electric vehicle has been the leading candidate for meeting the ZEV percentage requirements due to its stage of commercial development. Since 1990, worldwide effort in the research and development of vehicle and battery technology has greatly improved the prospects for the successful commercialization of electric vehicles. More recently, fuel cell technology has gained worldwide attention as a technology capable of supplanting current internal combustion engine vehicles in the market while providing zero direct emissions (when using stored hydrogen).

In 1998 the ARB modified the ZEV requirement to allow ZEV credit to be earned by vehicles with near-zero emissions, referred to as “partial ZEVs” (PZEVs). Staff believes that this partial allowance approach towards satisfying the ZEV requirement will promote the continued development of battery-powered electric and zero-emitting fuel cell vehicles, while encouraging the development of other advanced technology vehicles that have the potential for producing extremely low emissions. At the present time, only the Nissan Sentra ‘CA’ (“Clean Air”) has achieved California certification for PZEV credit. Several other vehicles have achieved SULEV-level exhaust emissions, but have not yet demonstrated compliance with the full set of PZEV requirements. Great progress has also been made on the development of gasoline-electric hybrid vehicles. Based on public announcements to date, however, staff does not believe that grid-charged hybrid-electric capability will be made available on any MY 2000-2003 vehicles.

Several classes of small on-road electric vehicles have begun to emerge in the last few years that will displace gasoline vehicle usage and increase overall zero-emission miles traveled within California. Examples of such vehicles include low speed vehicles (LSVs), neighborhood electric vehicles (NEVs), and city electric vehicles (City EVs). These vehicles are under consideration because they offer a number of desirable characteristics, including very high efficiency, affordability, the potential for reduced congestion, and many niche market applications. Under current state law and ARB regulation, NEV/LSVs and City EVs all qualify as “passenger cars” and therefore are eligible to earn full ZEV allowances. In terms of trip replacement and the resulting air quality impact, however, these vehicles differ, and are not the complete equivalent of full-range EVs. Therefore it is not clear that they should all be treated the same. ARB staff plan to evaluate the relative emissions benefit of the various categories of vehicles.

Battery Technology Assessment

The cost of batteries, both today and when produced in volume, is one of the most critical parameters of this review. To obtain the best available assessment, the ARB has contracted with a team of outside experts. This panel is in the process of meeting with leading battery suppliers and auto manufacturers. Their task is to review the state of the art regarding advanced battery design and manufacturing techniques, and report back to staff regarding likely cost trends for 2003 and beyond. Their draft final report will be presented at the May workshop.

The current structure of the ARB regulatory and incentive scheme for ZEVs and partial ZEVs is intended to encourage the development of advanced batteries that will allow battery EVs to achieve extended range. This approach has been taken in order to encourage the development of vehicles with sufficient range to cover the majority of trips taken by typical drivers. Some parties have argued that the ARB preference for advanced batteries should be revisited. Proponents of this view make the case that the most cost-effective application for battery EVs could be vehicles powered by lead acid batteries, and they question whether the

increased range afforded by advanced batteries justifies the extra cost. Others have argued that one appropriate niche for battery EVs could be smaller, shorter-range vehicles for urban and commuter use.

Infrastructure Assessment

To achieve zero and near-zero emission levels, together with minimal upstream refueling emissions, the advanced technology vehicles being developed by manufacturers often require the use of a "fuel" other than conventional gasoline. Therefore it will be critical to ensure that the necessary refueling infrastructure is in place to support their widespread introduction.

For electric vehicles the refueling infrastructure consists of charging stations. The public infrastructure for electric vehicle charging continues to expand in California. Currently, inductive electric charging stations and conductive electric charging stations are available at about 300 and 200 public locations, respectively.

To address fuel cell vehicle and infrastructure issues, in April 1999 California Governor Gray Davis and industry leaders announced the "California Fuel Cell Partnership - Driving the Future". The partnership is a collaboration of auto manufacturers, energy providers, a fuel cell company, the State of California, and the United States Department of Energy. In addition to testing fuel cell vehicles, the Partnership will also identify fuel infrastructure issues and prepare the California market for this new technology. A key goal of the Partnership is to determine the best fuel infrastructure for the market entry of fuel cell vehicles.

The EV Market

The EV driver experience provides important information to manufacturers, regulators and future customers on the utility and viability of EVs in the "real world". Lessons learned with the EVs placed to satisfy MOA obligations can be used to better define the future EV market place by educating potential customers, identifying necessary technology improvements, and identifying desirable EV platforms.

According to information submitted by the manufacturers, they have sponsored focus groups studies, market analyses, and mass surveys to identify potential EV customers. ARB staff is currently reviewing this material and will provide general descriptions of the results obtained from these various efforts in the next draft of this document.

Cost Information

Automakers have had many years to refine and reduce costs for the manufacture of internal combustion engines. Electric drive vehicles are just at the beginning of the cost reduction cycle.

After reviewing several cost models and research, ARB staff projects that the initial cost of battery electric vehicles in high-volume production will be higher than that of a conventional vehicle even under the most favorable conditions. This is due to the high cost of the battery pack that overwhelms the possibly slightly lower cost of the rest of the vehicle (in comparison to the conventional vehicle). A more detailed assessment will be provided following the submittal of the report of the external battery panel, and will be available for review and comment at the May workshop.

Cost is also the major issue facing the development of fuel cell vehicles. While these systems are currently extremely expensive, efforts are ongoing to meet stringent cost goals for every material, component and manufacturing process. Ultimately, the use of automated manufacturing will be necessary for all components and subsystems if these stringent cost goals are to be met. To date, automakers have not yet encountered any fundamental barriers to meeting these cost goals.

Although Partial ZEV vehicles at present also face a cost penalty, that penalty is less significant and is expected to be further reduced as production levels are increased. Hybrid vehicles, with two propulsion systems, will be more expensive to produce than PZEV certified conventional ICE vehicles. Due to their increased efficiency, hybrid vehicles will recover at least a portion of this cost penalty via reduced fuel cost, as will battery EVs and fuel cell vehicles.

Emission Benefit Information

This staff assessment provides preliminary information on per-vehicle emissions from battery electric vehicles and fuel cell vehicles vs. conventional vehicles. The Air Resources Board and the California Energy Commission currently have staff analyses and contract studies underway that will update and refine these estimates. These comparisons do not at present include “upstream” emissions from conventional vehicles due to fuel production and transfer, and vehicle refueling. Such estimates, which are also being updated in a contract study, will be included in the next iteration of this document.

To assess and update the fleet-level emissions benefits of the ZEV program, ARB staff will conduct a thorough emissions impact analysis, using the updated on-road emissions inventory model. The model, EMFAC2000, is scheduled for Board review and approval in April. Once the model is approved, ARB staff will prepare an emission impact assessment. The updated assessment will be

Preliminary Staff Assessment--Revised

incorporated into the next iteration of this document and will be on the agenda for public comment at the May workshop.

TABLE OF CONTENTS

1	INTRODUCTION	1
1.1	Background	1
1.2	The Zero Emission Vehicle Program	1
1.3	Shared Long-Term Vision	2
1.4	The Biennial Review Process	4
1.5	The Purpose of This Document	5
2	MANUFACTURER STATUS	7
2.1	Introduction	7
2.2	Manufacturer Volume Classifications	7
2.3	Potential Classification Changes	8
2.4	Multi-Manufacturer Ownership Arrangements	9
2.5	ZEV Production to Date by Major Manufacturers	9
2.6	ZEV Volume Estimates for 2003	12
3	COMPLIANCE WITH THE MEMORANDA OF AGREEMENT	15
3.1	Introduction	15
3.2	Manufacturer Commitments	16
3.3	Air Resources Board Commitments	21
3.4	Additional Air Resources Board Activities	33
4	VEHICLE TECHNOLOGY ASSESSMENT	36
4.1	Introduction	36
4.2	Pure ZEV Vehicles	36
4.3	Full and Partial ZEV Allowance Vehicles	40
4.4	On-Road Neighborhood and City Electric Vehicles	48
5	BATTERY TECHNOLOGY ASSESSMENT	53
5.1	The Battery Panel (Pending)	53
5.2	Range vs. Cost	53
6	INFRASTRUCTURE ASSESSMENT	54
6.1	Introduction	54
6.2	Battery Electric Vehicles	54
6.3	Grid-Connected Hybrid Vehicles	55
6.4	Fuel Cell Vehicles	55
6.5	Compressed Natural Gas Vehicles	56
7	THE EV MARKET	57
7.1	Introduction	57
7.2	The EV Driver Experience	57
7.3	Manufacturer Marketing Strategies (Pending)	60
7.4	Market Analysis (Pending)	61

8	COST INFORMATION (PRELIMINARY)	62
8.1	Introduction	62
8.2	Battery Electric Vehicles	62
8.3	Fuel Cell Vehicles	62
8.4	Partial ZEV Vehicles	63
8.5	Infrastructure	63
9	EMISSION BENEFIT INFORMATION (PRELIMINARY)	64
9.1	Introduction	64
9.2	Per Vehicle Emissions—Battery Electric Vehicles	64
9.3	Per Vehicle Emissions—Fuel Cell Vehicles	65
9.4	Emission Inventory Analysis	65
10	CONCLUSION	66
11	REFERENCES	67

1 INTRODUCTION

1.1 Background

Air quality in California has improved dramatically over the past 25 years, largely due to continued progress in controlling pollution from motor vehicles. Faced with ever more stringent regulations, vehicle manufacturers have made remarkable advances in vehicle technology. Several thousand zero-emission vehicles are now in everyday service on California roads, and the latest conventional internal combustion engine vehicles achieve emission levels that seemed impossible just a few short years ago.

Despite this progress, however, air quality in many areas of the state still does not meet federal or state health-based ambient air quality standards. Mobile sources still are responsible for well over half the ozone-forming emissions in California, and passenger cars and small trucks are responsible for a significant portion of the mobile source contribution. State and federal law requires the implementation of control strategies to attain ambient air quality standards as quickly as practicable.

1.2 The Zero Emission Vehicle Program

The Zero Emission Vehicle (ZEV) program was originally adopted in 1990, as part of the first ARB Low-Emission Vehicle regulations. The ZEV program is an integral part of California's mobile source control efforts, and is intended to create a market for advanced technologies that will secure increasing air quality benefits for California now and into the future. ZEVs have significant long-term benefits because they have no emission control equipment that can deteriorate or fail, and generate only minimal "upstream" refueling and fuel cycle emissions.

Under the 1990 regulations, the seven largest auto manufacturers were required to produce ZEVs beginning with model year 1998. In model years 1998 through 2000, two percent of the vehicles offered for sale in California by large volume manufacturers were to be ZEVs, and this percentage was to increase to five percent in model years 2001 and 2002, and ten percent in model years 2003 and beyond.

In 1996 the ARB modified the regulations to allow additional time for the technology to develop. The requirement for ten percent ZEVs in model years 2003 and beyond was maintained. In lieu of the sales requirement for model years 1998 through 2002, however, the ARB entered into Memoranda of Agreement (MOAs) with the seven largest vehicle manufacturers. Under the MOAs the manufacturers must place more than 1,800 advanced-battery EVs in California in the years 1998 through 2000, and the ARB must work with state and local governments to help develop ZEV infrastructure and remove barriers to ZEV introduction.

In 1998 the ARB provided additional flexibility in the ZEV program by allowing additional types of vehicles to be used to meet program requirements. Under the 1998 amendments, manufacturers can use extremely clean advanced-technology vehicles (referred to as “partial” ZEVs) to meet the 10 percent ZEV requirement, except that large-volume manufacturers must, at a minimum, have 4 percent of their sales be vehicles classified as “full” ZEVs.

1.3 Shared Long-Term Vision

Simply put, continued reliance on today’s technology will not allow California to reach its health-based air quality goals. In ARB’s vision of the future, therefore, the entire vehicle fleet will produce zero tailpipe emissions, and will use fuels with minimal “fuel cycle” emissions (emissions that occur due to vehicle refueling and the related production or transportation of fuel). As an ancillary benefit to the advanced technologies employed, the future vehicle fleet also will be highly energy efficient, use diverse energy sources, and will result in reduced emissions of greenhouse gases.

Based on staff conversations and briefings with the major automobile manufacturers, it appears that they share this vision. There is a general consensus that global customer demands will reward companies that can meet society’s transportation needs while eliminating harmful environmental impacts. Thus, although there may be disagreements over the pace of change and the path to be followed, the ultimate goal is not in question.

1.3.1 Continued Emphasis on Zero Emissions

Battery-powered electric vehicles and other ZEVs such as hydrogen fuel cell vehicles hold distinct air quality advantages over technologies that use a conventional fuel such as gasoline in a combustion engine. High volatility liquid fuels such as gasoline are responsible for significant fuel cycle emissions. Vehicles with combustion engines inevitably exhibit deterioration that results in increased emission levels as the vehicle ages. They are also subject to becoming gross polluters if critical emission control systems fail. Although new vehicles have more durable emission control systems and on-board diagnostic systems that are effective in alerting owners to emission related problems, owners may not respond to failure signals promptly. The inspection and maintenance program will not capture vehicles that are operated without being registered, and repair cost limits may permit continued operation of some high emitting vehicles.

For all of these reasons, vehicles with no potential to produce emissions are the “gold standard” of even the cleanest, most advanced new technologies. The commercialization of ZEVs is critical to the long-term success of California’s clean air program. Even with the full implementation of the LEV II program, emissions from light duty vehicles will still represent a significant portion of total

emissions in the South Coast Air Basin. Achieving the new air quality standards for particulate matter, not to mention the state ozone standard, will require further reductions. Taking into account the anticipated growth in the number of light-duty vehicles and the number of miles they travel each day, it is clear that we need to eliminate emissions related to vehicle deterioration and fuel use from a significant portion of the light-duty vehicle fleet. ZEVs can accomplish this goal.

1.3.2 Near-Zero Technologies Also Play a Major Role

The ZEV requirements have been instrumental in promoting battery, fuel cell, component and vehicle research and development. These requirements have also been successful in spawning a large variety of extremely low-emission vehicle technologies. Many of these technologies have at least some of the desirable qualities inherent to ZEVs, such as extremely low emissions of smog precursors and toxic air contaminants, reduced emissions of greenhouse gases, extended durability, or high efficiency.

Such vehicles will play a major role in achieving further air quality improvement. First of all, because many of the technologies can be adopted at relatively low cost, vehicles using these technologies have the potential for widespread early market penetration without the need for subsidies or other incentives. Although the near-ZEV vehicles are not as clean as ZEVs, if produced in large numbers they provide a significant air quality benefit relative to the conventional vehicles that they replace.

Second, because many of these vehicles use components also found on zero emission vehicles (e.g. battery packs, controllers, and electric drive), volume production of near-zero vehicles will help reduce the cost of components used on zero emission vehicles and hasten their commercialization.

1.3.3 Linkage to Broader Issues

The mission of the Air Resources Board is to protect public health through the reduction of air pollution. The Board's primary focus is on the reduction of smog-forming pollutants and toxic air contaminants. To date, most discussion of ZEV air quality impacts has focused on their smog benefits.

In addition to their dramatic reduction in smog-forming pollutants, ZEVs also provide reductions in the emissions of toxic air contaminants. The benefits of reductions in toxic air contaminants are felt statewide. Recognizing that mobile source pollution may disproportionately affect inner city and low-income neighborhoods, however, reductions in toxic emissions from motor vehicles can help address community level public health concerns.

Above and beyond these traditional air pollution benefits, ZEVs can also make significant positive contributions in other environmental areas. For example, the

use of alternative fuels can reduce the multimedia impact of fuel spillage on water quality, and can increase the diversity of California's energy supply. The smooth, quiet operation of electric drive vehicles can improve the quality of life in crowded urban areas. Electricity and hydrogen, which can be used to power ZEVs, can be produced from renewable resources such as solar, wind or hydropower, or biomass feedstocks. Thus these technologies can help pave the way towards a sustainable energy future.

Perhaps the most important ancillary benefit, though, is that high-efficiency ZEVs and near-ZEVs can lead to significant reductions in emissions of CO₂ and other greenhouse gases. The Air Resources Board does not currently regulate emissions of greenhouse gases. The Board is, however, working with the California Energy Commission to better understand the contribution of mobile sources to total greenhouse gas emissions, and quantify the climate change impact of various fuels and vehicle technologies. Even in the absence of specific regulatory requirements it is clear that, other things being equal, technologies that achieve lower greenhouse gas emissions are the preferred alternative. Meanwhile, auto manufacturers worldwide are working to reduce greenhouse gas emissions from their vehicles in keeping with the Kyoto Protocol and other requirements in place or pending in other markets.

ZEVs also can benefit California's economy as well as our public health. Because of their high-technology leadership, California companies have the technical and scientific capability to play a significant role in the design, development and production of advanced technology zero emission components and vehicles.

ZEVs thus have the capability to provide comprehensive environmental, energy and societal benefits. While the Board's consideration of the ZEV regulation is firmly rooted in its air quality mandate and authority, the Board is aware of the multi-faceted effects of its policy choices. Over the long term the Board, in cooperation with its sister agencies, will devote increasing attention to an integrated consideration of such broader issues.

1.4 The Biennial Review Process

When the ZEV requirement was adopted in 1990, low- and zero-emission vehicle technology was in a very early stage of development. The Board acknowledged that many issues would need to be addressed prior to the implementation date. Thus the Board directed staff to provide an update on the ZEV program on a biennial basis, in order to provide a context for the necessary policy discussion and deliberation. The next biennial review of the ZEV program is scheduled for September 2000.

The ARB is committed to working closely with all interested parties to ensure that they have an opportunity to provide comments and suggestions throughout the review process. The key milestones of the review process are as follows:

Preliminary Staff Assessment--Revised

March 29, 2000	Public Workshop Background Information for the September Review Sacramento
March 30, 2000	Public Workshop Multi-Manufacturer Ownership Arrangements Sacramento
May 31, 2000	Public Workshop Background Information for the September Review El Monte
July 2000	Staff Report released to the public
September 7, 2000	Board Meeting

1.5 The Purpose of This Document

In preparing for the Board's upcoming Biennial Review, the goal of the staff is to provide a thorough, accurate portrayal of the current status of ZEV technology and the prospects for improvement in the near- and long-term. Extensive staff work is underway in a variety of areas. Staff efforts to date have included meetings with vehicle manufacturers, environmental groups, and other interested parties, on-site visits to the major vehicle manufacturers in Japan and in Detroit, discussions with EV drivers, and research on current and pending technologies and their environmental impacts. ARB also has contracted with outside technical experts to review the state of battery technology and production costs, and assess the full fuel cycle emissions and energy efficiency of various vehicle types and fuel sources.

This document outlines the information developed to date, and describes other efforts underway that will provide additional information as the review proceeds. This staff assessment provides a snapshot of the status of our work at this point in time. Some portions are in near final form, while other portions provide a general outline that will be filled in as additional information is collected. In particular, the battery technology, cost, emission benefit, and EV market sections of this document will be significantly expanded and revised when ongoing work is completed. Thus a complete assessment of the full range of relevant issues will be first presented in the next iteration of this document, in time for the May workshop.

This document is descriptive rather than proscriptive—it does not draw conclusions or make recommendations. Rather, the purpose of this staff assessment is to put forth technical information for public review and comment, develop a framework and context for consideration of the relevant issues, and

Preliminary Staff Assessment--Revised

provide an opportunity for interested parties to point out any errors, omissions, or other problems in the factual basis that will be made available to the Board.

Comments are welcome on all aspects of this material. Following the March public workshop and the review of all comments received, staff will make changes as appropriate and release a preliminary draft of the Staff Report and the accompanying Technical Support Document prior to the May workshop. After discussion at the May workshop and the consideration of all comments received, staff will release the final Staff Report and Technical Support Document in July. By following this process we hope to provide a firm, agreed-upon technical basis for the Board's policy review and discussion at the September Board meeting.

2 MANUFACTURER STATUS

2.1 Introduction

The ZEV requirement applies to large and intermediate volume manufacturers (defined below). Beginning in model year (MY) 2003, at least 10 percent of the passenger cars and light duty trucks below 3750 pounds vehicle weight produced and delivered for sale in California by large and intermediate volume manufacturers must be ZEVs. An intermediate volume manufacturer may meet this ZEV requirement entirely with partial ZEV allowance vehicles (defined in Section 4.3.1) or credits generated by such vehicles. A large volume manufacturer must meet at least 40 percent of its ZEV requirement with pure ZEVs, full ZEV allowance vehicles, or credits generated by such vehicles. Large volume manufacturers may, at their option, meet the remaining 60 percent of their ZEV requirement with partial allowance vehicles or credits generated by such vehicles. A small volume manufacturer is not required to meet the percentage ZEV requirements, but may earn and market credits for the ZEVs or ZEV allowance vehicles it produces and delivers for sale in California.

2.2 Manufacturer Volume Classifications

Because MY 2003 is quickly approaching and planning for MY 2003 production has already begun, ARB staff has attempted to establish each manufacturer's volume classification and, thus, each manufacturer's ZEV requirement.

For purposes of classification for 2003, small volume manufacturers are defined as those with California sales below 4,500 per year, using the average number of vehicles sold over the preceding three years. Small volume manufacturers are not subject to the ZEV requirement. Based on current production and sales data, ARB staff expects the small volume manufacturers in MY 2003 to be the following:

- Dae Woo Motor Company
- Ferrari
- GFI
- Lamborghini
- Lotus
- Porsche
- Rolls Royce
- Saab
- Suzuki

Intermediate volume manufacturers are defined for 2003 as those with California sales between 4,501 and 35,000 light and medium duty vehicles per year, again averaged over the preceding three years. Based on the same data, ARB staff expects the intermediate volume manufacturers in MY 2003 to be the following:

- BMW
- Subaru (Fuji)
- Hyundai
- Isuzu
- Jaguar
- Kia
- Mazda
- Mitsubishi
- Rover
- Volkswagen
- Volvo

Large volume manufacturers are defined as those that are not small volume manufacturers or intermediate volume manufacturers. Based on the same data, ARB staff expects the large manufacturers in MY 2003 to be the following:

- DaimlerChrysler
- Ford
- GM
- Honda
- Nissan
- Toyota

2.3 Potential Classification Changes

Although historically categorized as a large-volume manufacturer, Mazda has consistently been selling fewer than 35,000 vehicles in California in recent years. Mazda will be considered an intermediate volume manufacturer beginning in MY 2003 if its production volume remains at the current level.

BMW and Volkswagen have each been selling more than 35,000 vehicles in California in recent years. If these sales levels are sustained such that their 2000 through 2002 MY average sales exceed 35,000, they will need to meet ZEV requirements as large volume manufacturers beginning in MY 2006.

Subaru, which is currently considered an intermediate volume manufacturer, has been selling near the lower limit of the intermediate volume manufacturer classification in California in recent years. Therefore, depending on its actual sales in model years 2000 through 2002, Subaru may be classified as either an intermediate or a small volume manufacturer in MY 2003.

In 1998 Isuzu produced only light duty trucks between 3751 and 5750 pounds gross vehicle weight (LDT2s), which are not subject to the ZEV requirement. Rover produced only medium duty vehicles, also not subject to the ZEV

requirement. Therefore, although Isuzu and Rover are intermediate volume manufacturers, they will not need to produce any ZEVs in MY 2003 if they continue to produce only LDT2 and medium duty vehicles.

2.4 Multi-Manufacturer Ownership Arrangements

In recent years there have been many new multi-manufacturer arrangements, which have made it difficult to delineate individual companies. For example:

- Ford fully owns Volvo and Jaguar, and partially owns Mazda
- General Motors fully owns Saab, and partially owns Suzuki
- BMW fully owns Rover
- Nissan is fully owned by Renault
- Volkswagen fully owns Rolls Royce
- Kia is partially owned by Hyundai, Ford, and Mazda

To clarify the ZEV-related emission compliance liabilities of companies in multi-manufacturer arrangements, ARB staff will hold a workshop on March 30, 2000. The resulting policy will be implemented either by regulatory amendments or through issuance of a Manufacturer's Advisory Correspondence. Appropriate lead time will be provided before any changes become effective.

2.5 ZEV Production to Date by Major Manufacturers

The ZEVs that have been placed in California by major manufacturers are described in the following table.

Manufacturer	Model	Battery Type	Lease Cost (\$)	City Range	Highway Range	Number Placed
Daimler Chrysler	EPIC	PbA	NA	70	65	17
	EPIC	NiMH	450	92	97	97
Ford	Ranger	PbA	varied	84	69	51
	Ranger	NiMH	450	94	86	308
GM	EV1	PbA (Delco)	349	75	78	460
	EV1	PbA (Panasonic)	424	111	113	0
	EV1	NiMH	499	143	152	162
	S-10	PbA	439	46	43	110
	S-10	NiMH	440	92	99	76
Honda	EV Plus	NiMH	455	125	105	330
Nissan	Altra	Lilon	599	120	107	37
Toyota	RAV4	NiMH	457	142	116	486

Please note that all range figures used in this document are based on the urban dynamometer driving schedule (UDDS) and the highway fuel economy driving

schedule (HFEDS) test cycles. Lease prices shown include governmental incentives. Information regarding the number of vehicles placed is somewhat out of date in this draft, and will be updated after the manufacturers submit their 1999 annual reports in late March.

Overall, manufacturers have adopted similar strategies to make these vehicles attractive to customers. The vehicles typically are available via a three-year lease. This reduces the risk to the customer that their vehicle will be obsolete in a few years due to technical advances. Similarly, the warranty provided on the vehicles is comprehensive, and covers all components. This eliminates any durability issues or concerns on the part of the customer. Finally, the lease typically includes roadside assistance services.

Because production levels for these vehicles are not yet sufficient to justify assembly line tooling and manufacturing techniques, the vehicles have been produced in a "batch" process. Under this method, a small quantity of vehicles (several hundred) is built at one time. A new batch is produced when necessary.

A few details regarding the specific activities of each manufacturer follow.

DaimlerChrysler

To meet its MOA commitment, DaimlerChrysler began to place MY 1999 NiMH battery-powered Electric Powered Interurban Commuters (EPICs) in the 1998 calendar year. DaimlerChrysler chose the minivan platform for the EPIC because of the popularity of DaimlerChrysler's minivans and because of the minivan's versatility to either carry passengers or to be used as a utility vehicle. DaimlerChrysler has also been researching and demonstrating the potential use of conductive 'fast charge' technology. Using this fast charge capability, the EPIC is capable of more than 300 miles service in a single day. The EPIC is marketed to fleet customers only.

Ford

Ford first introduced its lead-acid battery-powered version of the Ranger EV pickup truck in 1998. The NiMH version was made available in 1999. Ford has entered into an agreement with the United States Postal Service to provide 500 electric vehicle platforms, based on the Ford Ranger, for use as Postal Service vehicles. Most recently, Ford has announced plans to market the two passenger Th!nk City and Th!nk Neighbor vehicles in the United States—the first vehicles of that type to be offered by a major automobile manufacturer in this country. Although lead-acid Ranger EVs and postal vehicles do not count towards the MOA requirement, they generate credits towards Ford's MY 2003 ZEV requirement. The Ranger is marketed to fleet customers. The Th!nk vehicles will be marketed to the general public.

General Motors

General Motors introduced the first production battery-powered vehicle—the EV1—in 1996. The S-10 truck was introduced in 1997. In MY 1999, GM began offering second-generation EV1s with two battery choices—an advanced lead-acid battery pack and a NiMH battery pack. Currently, 33 Saturn retailers in Los Angeles, Orange County, San Diego, the San Francisco Bay area, Sacramento, Phoenix and Tucson lease and service the EV1. Although lead-acid battery-powered EV1s and S-10s are not eligible for MOA ZEV credit, they generate credits that can be used towards the requirement for ten percent ZEVs in 2003. The EV1 is marketed to the general public, while the S-10 is marketed to fleets.

On March 2, 2000 GM announced that it had decided that a defect which relates to motor vehicle safety exists in all 1997 Generation I, EV1 and 1997-98 S-10 Electric Truck vehicles. GM stated that these vehicles were produced with a charge port assembly that may fail during a charging event. If this occurs, heat could build up within the charge port and a fire could result without prior warning. GM urged drivers to park their vehicles and immediately discontinue any and all vehicle charging. GM specialists have been notifying drivers to make arrangements for vehicles to be returned to an authorized GM location, assist in the termination of leases, and discuss immediate transportation needs. As of this writing the final disposition of the vehicles and arrangements for replacement transportation have not been determined.

Honda

In 1999, Honda completed its MOA commitment and finished placing the last of its Honda EV Plus vehicles. Although Honda does not plan to continue production of the EV Plus at this time, it maintains the capability to resume production. Honda currently is focusing its efforts on EV Plus customer satisfaction issues, which will continue at least until the end of the vehicle leases. The EV Plus has been marketed in the Los Angeles area, San Diego, Sacramento, and the San Francisco Bay Area, and has been equally targeted toward the consumer market and to fleets.

Nissan

Nissan plans to fulfill its MOA commitment by the end of calendar year 2000 with the lithium ion battery powered Nissan Altra EV. The Nissan Altra EV is the first production electric vehicle that is equipped with lithium-ion batteries. After the initial California placement in 1998, Nissan decided to change to a different lithium-ion battery supplier. Due to efforts in making this change, Nissan did not produce any MY 1999 Altras. The new battery pack was incorporated in MY 2000 and was introduced in California in December 1999. Altra EVs are available to select California fleet users.

Toyota

The RAV4 EV is a five-door, four-passenger sport utility-like vehicle powered by NiMH batteries. In April 1999, Toyota announced that it had completed its MOA commitment. Toyota will continue product development and gather in-use information about range, performance and market acceptability of the RAV4 EV. The RAV4 EV is only available to fleet operators. Any vehicles placed in addition to Toyota's MOA obligation will generate credits towards the 2003 requirement.

Mazda

To date, Mazda has purchased credits to meet its MOA obligations and therefore has not offered any ZEVs under the Mazda nameplate.

2.6 ZEV Volume Estimates for 2003

California sales of passenger cars plus light duty trucks by the major automobile manufacturers total approximately one million vehicles per year. As a rule of thumb, therefore, each one percent of vehicle sales equals about ten thousand vehicles per year.

The calculation of the actual number of vehicles needed to meet the ZEV requirement in any given year is considerably more complex, however, due to several factors:

- Manufacturers can earn "multipliers" for vehicles with extended range, with additional allowances for vehicles delivered prior to 2003. Taken together these two factors can result in up to 10 allowances per vehicle for vehicles delivered in MY 2000. Specifically, each ZEV and full ZEV allowance vehicle that is produced and delivered for sale in California in the 1999 to 2007 model years and that has an extended electric range qualifies for a ZEV multiplier as shown below. These multipliers are based on range alone and are not dependent on the type of battery or the battery specific energy.

All-electric range	MY 1999-2000	MY 2001 -2002	MY 2003-2005	MY 2006-2007
100-175	6-10	4-6	2-4	1-2

- Manufacturers are given one additional model year to make up any shortfall in ZEV production. Thus, a manufacturer could choose to satisfy both its 2003 and 2004 obligation with vehicles delivered in 2004.
- In order to meet their obligation, major manufacturers must offer for sale a minimum of 4 percent pure ZEVs. They may, however, choose to meet the entire 10 percent requirement using pure ZEVs.

Preliminary Staff Assessment--Revised

To provide a context for the Board's evaluation of the ZEV program, staff have developed a "base case" estimate of the number of ZEVs that the major manufacturers must produce in 2003 in order to satisfy the 4 percent ZEV requirement. Due to trade secret considerations this estimate does not rely on any confidential information provided in the manufacturer product plans. Instead, it is calculated using publicly available information, with the following assumptions:

- The vehicles offered for sale in 2003 are identical in performance to the vehicles currently or most recently offered by the manufacturers. (The specific vehicles, their test cycle range, and the resulting number of allowances earned per vehicle are shown below.)
- Manufacturers do not take advantage of the multipliers available for early introduction; the entire 2003 obligation is met with vehicles produced in 2003.
- Each manufacturer's production volume in 2003 is equal to its production volume in 1998.
- Manufacturers meet 60 percent of their ZEV obligation using partial ZEV allowances, and 40 percent of their obligation (4 percent of sales) using pure ZEVs. (An estimate assuming that manufacturers meet their entire 10 percent obligation with pure ZEVs, using no partial ZEV allowances, is shown for comparison purposes.)

With these assumptions, 2003 pure ZEV production would be as follows:

Manufacturer	1998	ZEV model	Urban	Multiplier	2003 ZEV	
	Production				4%	10%
	(PC+LDT1)		(miles)			
GM (see note 1)	84,106	1999 NiMH EV1	143	3.144	1,070	2,675
	84,106	1999 PbA EV1	111	2.293	1,467	3,667
	42,053	1999 NiMH S10	92	1.000	1,682	4,205
TOYOTA	201,473	1998 RAV4 EV	143	3.141	2,565	6,414
FORD	186,977	1999 NiMH Ranger	71	1.000	7,479	18,698
HONDA	172,768	EV Plus	125	2.672	2,586	6,466
NISSAN	88,455	2000 Altra	129	2.773	1,276	3,189
DAIMLER CHRYSLER	105,691	1999 NiMH EPIC	92	1.000	4,228	10,569
TOTAL	965,630				22,353	55,884

Note 1: This estimate assumes that GM sales are 40% NiMH EV1, 40% Panasonic PbA EV1, and 20% NiMH S10.

This estimate, at roughly 22,000 vehicles, corresponds to about 2.3 percent of the passenger car and light duty truck production of the affected manufacturers.

It must be noted, however, that actual 2003 ZEV production may vary significantly from this number due to the various factors discussed above.

Manufacturers are required, under the Memoranda of Agreement with the ARB, to submit confidential product plans outlining the product mix that they will use to meet the 2003 requirement (see Section 3.2.3 below). All manufacturers submitted these plans on a timely basis. All manufacturers demonstrated that they have the technical capability to produce the quantity of vehicles needed to meet their 2003 obligation. The manufacturers uniformly argued, however, that the cost of these vehicles remains high, and foreseeable battery technology will result in limitations on vehicle range. Thus in their view it will be difficult to develop a self-sustaining mass market for battery electric vehicles at this time.

Staff notes that technical advances are steadily reducing the cost premium associated with ZEVs and that increased production volume will bring about further reductions. Because the status of battery technology is central to any discussion of cost and feasibility, such issues will be addressed more completely in the next iteration of this document, following the receipt of a report from a panel of outside experts that is reviewing battery cost and performance.

3 COMPLIANCE WITH THE MEMORANDA OF AGREEMENT

3.1 Introduction

In 1996, the Executive Officer of the Air Resources Board and all seven major auto manufacturers signed Memoranda of Agreement (MOAs). The major auto manufacturers who signed the MOAs are General Motors, Ford, Chrysler (now DaimlerChrysler), Honda, Nissan, Toyota, and Mazda. The MOAs are intended to ensure the successful introduction of zero emission vehicles into the marketplace. They include binding commitments from each of the seven auto manufacturers as well as from ARB.

Under the MOAs, the auto manufacturers must:

- Offset the emission benefits lost due to the elimination of the ZEV requirement for 1998 through 2002;
- Participate in a market-based ZEV launch by offering ZEVs to consumers in accordance with market demand;
- Submit annual progress reports, and biennial product plans outlining how they will comply with the 2003 requirement;
- Participate in a technology development partnership, including continued investment in ZEV and battery research and development, and placement of advanced battery-powered ZEVs in marketplace demonstration programs;
- Collaborate with the ARB and the State Fire Marshal on ZEV safety training; and
- Provide the ARB with an on-site review of manufacturer activities and hardware related to the ZEV program.

The ARB, meanwhile, committed in the MOAs to working with state and local governments and others to help develop ZEV infrastructure and remove barriers to ZEV introduction. Specifically, the ARB must:

- Facilitate the purchase of ZEVs in state fleets;
- Address insurance and financing issues;
- Work with other state agencies to ensure the availability of battery recycling;
- Work with local governments on planning and permitting of charging stations;
- Work with utilities and electrical contractor trade groups to ensure adequate training for installation and maintenance of EV charging systems;
- Support the efforts of the National Electric Vehicle Infrastructure Working Council;
- Work with the State Fire Marshal and other emergency response officials to create a comprehensive ZEV emergency response training program;
- Observe the activities of the U.S. Advanced Battery Consortium; and
- Support the development and implementation of reasonable incentive programs that enhance the near-term marketability of ZEVs.

3.2 Manufacturer Commitments

All of the major auto manufacturers submitted the annual reports and the product plans as required. These reports outline the progress made towards meeting the requirements of the MOAs. The following information is based on the manufacturers' submittals as well as private meetings and phone conversations with manufacturers.

Staff concludes that the manufacturers and the ARB have met the commitments made in the MOAs. The remainder of this chapter provides detail on the individual tasks.

3.2.1 Cleaner Cars Nationwide (National Low-Emission Vehicle Program)

The MOAs require the auto manufacturers to introduce low-emission vehicles nationwide in 2001, three years earlier than could be required under federal law. The National Low Emission Vehicle (NLEV) program was included in the MOAs to offset the emission increases associated with the 1996 revisions to the ZEV program, and thereby maintain the integrity of ARB's State Implementation Plan. Because non-California vehicles frequently travel through California or relocate to California from other states, cleaning up non-California vehicles results in emission reductions within California's borders. A 1996 ARB staff analysis indicates that by 2010 the NLEV program will result in emission reductions that are equivalent to those that would have occurred had the original ZEV program production requirement for 1998 through 2002 remained in place.

In March 1998, the U.S. Environmental Protection Agency (EPA) announced that 23 automobile manufacturers--including the seven manufacturers that signed the MOA--and nine northeastern states have agreed to the new voluntary NLEV program. Starting in 1999, light-duty vehicles and light light-duty trucks sold in the northeast are meeting more stringent emission requirements. The program will be expanded nationally in 2001. This agreement between the EPA and the auto manufacturers will fulfill the MOA obligation.

3.2.2 Market-Based ZEV Launch

The MOAs express the auto manufacturers' commitment to have the capacity to produce specified numbers of ZEVs--in addition to the demonstration vehicles discussed under Section 3.2.4.2 below--"that could be sold in California if warranted by customer demand" (Section I.B.). The purpose of this element of the MOA was to ensure that manufacturers have the production capacity to meet market demand for ZEVs during the ramp-up period prior to 2003. Attached to each MOA as Exhibit A was the manufacturer's confidential November 1995 submittal identifying the manufacturer's annual capacity to produce ZEVs for the 1996 through 2002 model years, in accordance with their estimate of market readiness.

The timing of vehicle introduction by the various manufacturers has varied, based upon the type of vehicle, the battery employed, specific technical challenges that needed to be overcome, and near-term targeted markets. As of January 2000, Ford, General Motors, Honda and Toyota have placed vehicles above and beyond those required under the MOA demonstration program.

The RAV 4, Altra and EPIC vehicles are currently only marketed to fleets, and production quantities are limited. Honda has announced that it will not produce additional vehicles, and will focus its efforts on evaluating customer satisfaction and providing customer support for vehicles currently in service. The net result of these manufacturer actions is that fleet customers face limited product availability, and the only vehicle currently available to retail customers is the EV1. Thus there is no four passenger, family vehicle available to the public.

The manufacturers have concluded that those most likely to lease the current ZEV products are fleet managers, or a small subgroup of highly educated, high-income "early adopters". Thus most marketing efforts have been targeted at these specialized groups, rather than at the general public.

Some parties have argued that the limited vehicle advertising and the limited availability of vehicles constitutes evidence that manufacturers are not complying with their MOA commitment to have the capacity to produce vehicles to meet customer demand.

As defined in the MOA, *"Capacity to produce" means that the manufacturer has available adequate vehicle production facilities either in-house or contractually with others, including the in-house ability or outside contracts sufficient to supply major vehicle parts and component needs. "Capacity to produce" does not obligate the manufacturer to produce, deliver or sell a specified number of ZEVs.* (Definitions, Section X.D.). A lack of available product therefore does not in and of itself signify noncompliance with the MOA.

An evaluation of compliance with the market-based ZEV launch requirement of the MOAs also requires an interpretation of the phrase "if warranted by customer demand". In the view of staff, a reasonable interpretation of customer demand implies demand that exists when the vehicle is priced at or near the manufacturer's cost. The current lease rates for the vehicles do not recover the relatively high cost of producing an EV today. Although it is common for manufacturers to sell some vehicles at a loss for larger corporate strategy purposes, the current differential between the lease prices for battery electric vehicles and the manufacturers' cost is substantial. Manufacturers have used various methods to determine the lease prices used for today's vehicles, but in no case have the vehicles been priced at a level that is close to the manufacturers' cost. Although we do not know what demand would exist if the vehicles were priced to recover at least the majority of their cost, presumably it would be less than that seen over the past several years.

In sum, staff concludes that manufacturers are in compliance with their commitment to have the capacity to produce vehicles that could be sold in California if warranted by customer demand.

3.2.3 Zero Emission Vehicle Product Plans

Under the MOAs, the manufacturers are required to submit ZEV product plans prior to November 1 of the year preceding the scheduled review (in this instance, prior to November 1, 1999). Each manufacturer must submit corporate product plans that demonstrate compliance with the ZEV requirement for 2003. All of the manufacturers submitted the required plans on a timely basis. The product plans identify the manufacturers' strategies for 2003, including key decision points and other milestones.

ARB staff have carefully reviewed the product plan submittals. Staff also made site visits to Japan and Michigan to tour the manufacturers' research and development facilities, and receive briefings on their research efforts. Based upon the review and site visits, staff is confident that the product plans accurately represent the status of work at the manufacturers.

The information in these confidential product plans provides part of the basis for the staff assessment of the current status of ZEV technology, discussed elsewhere in this document.

3.2.4 Technology Development Partnership

Under the Technology Development Partnership component of the MOA, the auto manufacturers agreed to make good faith efforts to promote and develop a market for ZEVs and to ensure ongoing ZEV-related research and development. To accomplish this effort, each manufacturer committed to continue battery research and development throughout the term of the MOA, and to place new ZEVs with advanced technology batteries into service in California through the advanced technology battery demonstration project.

3.2.4.1 Research and Development

All of the major manufacturers have extensive internal research and development efforts underway. The briefings and staff site visits in Michigan and Japan conclusively demonstrated that all manufacturers are actively pursuing a full range of zero and near-zero emission vehicle technologies. The extensive staffing levels and other resource commitments dedicated to advanced technology give evidence of the manufacturers' conviction that customer demands will force ongoing environmental improvement. Staff was impressed with the intense work underway in a variety of program areas, and the commitment by all manufacturers to play a leadership role in the commercialization of zero and near-zero emission vehicles.

In addition to in-house efforts, under the terms of the MOA General Motors committed to contribute \$8.9 million during Phase II of the United States Advanced Battery Consortium (USABC), while DaimlerChrysler and Ford have committed \$3.34 and \$6.67 million respectively. All three manufacturers are on target with their contributions and will completely contribute the full amounts by 2002.

3.2.4.2 Advanced Technology Battery Demonstration Project

The auto manufacturers each also agreed to produce their pro-rata share of up to 3,750 advanced battery vehicles between 1998 and 2000, and place them in demonstration programs designed to validate the new technology. Table 3-1 on the next page shows each manufacturer's share of the total ZEVs to be placed in demonstration programs.

To receive MOA ZEV credit towards the commitments enumerated in Table 3-1, a ZEV must use advanced batteries. For the purposes of the MOAs, "advanced battery" means a battery with a specific energy of at least 40 watt-hours per kilogram (Wh/kg) for the 1998 calendar year and at least 50 Wh/kg for 1999 and subsequent calendar years. (Specific energy is the amount of energy per unit of weight and is related directly to range).

Table 3-1 Auto Manufacturer MOA Advanced Battery Demonstration Commitments								
Calendar Year	Number of Vehicles (Based on Average Market Share)							Total by Year
	Chrysler	Ford	General Motors	Honda	Mazda	Nissan	Toyota	
1998	51	181	182	101	28	70	135	748
1999	103	363	365	202	55	141	271	1,500
2000	103	363	366	203	55	141	271	1,502
Total								3,750

The amount of credit given in the MOA for an advanced battery-powered ZEV is based on the specific energy of the batteries. Manufacturers may reduce the total number of ZEVs required if the batteries used in the vehicles have a specific energy greater than 50 Wh/kg. Table 3-2 on the next page indicates the number of credits that are granted for ZEVs that use advanced batteries.

Table 3-2 MOA ZEV Credits Allowed for an Advanced Battery-Powered ZEV	
Specific Energy	Number of ZEV credits allowed
40 Wh/kg (1998 only) 50 Wh/kg (1999 and 2000)	One
60 Wh/kg	Two
90 Wh/kg	Three

The advanced battery-powered vehicles that are being produced today have specific energy ratings of between 55 and 85 Wh/kg depending on the battery technology used. It is expected that advanced battery-powered EVs to be marketed in 2003 will fall approximately within this range as well.

Linear interpolation is used to determine the number of MOA credits earned by ZEVs with specific energy over 50 Wh/kg. Therefore, ZEVs placed as part of the Technology Development Partnership are generating from 1.5 to 2.8 MOA ZEV credits per vehicle. As a result, the actual number of vehicles to be produced to meet the auto manufacturers' advanced battery vehicle MOA commitments will be approximately 1,800 rather than 3,750.

In early 1999, both Honda and Toyota completed placement of advanced battery-powered electric vehicles for the Technology Development Partnership. General Motors, Ford, DaimlerChrysler and Mazda are on track to complete their commitments by the end of 2000. Nissan requested and received approval to delay placement of a small portion of their vehicles for one year (until 2001) due to a battery supplier issue.

As of January 2000 there were already more than 1300 advanced battery electric vehicles placed in California as a result of this project. At the conclusion of the project, there will be more than 1800 electric vehicles operating on advanced technology batteries on the roads of California.

3.2.5 Annual Reports

The MOAs require manufacturers to file an annual report within 90 days after the close of each calendar year. The annual reports must provide information regarding ZEVs placed in California and elsewhere in the United States during the previous calendar year. The annual report must also contain information regarding the placement of ZEVs under the Technology Development Partnership. All manufacturers have submitted their annual reports as required.

3.2.6 Collaboration with ARB and State Fire Marshal

The MOAs require manufacturers to collaborate with the ARB and the State Fire Marshal to develop the curriculum and materials necessary for a comprehensive ZEV safety-training program. This training program was completed in 1998.

3.2.7 On-Site Review

The MOAs require the manufacturer to provide ARB staff with an on-site review of activities and hardware related to the manufacturer's ZEV program. ARB staff visited Honda, Nissan and Toyota facilities in Japan in December 1999, and visited General Motors, Ford and DaimlerChrysler facilities in Michigan in February 2000. During these visits ARB staff received extensive briefings on the manufacturers' activities, and had the opportunity to view and/or test-drive a variety of vehicles. As a result of these visits and the information that has been provided, ARB staff have a thorough understanding of the status of work at each manufacturer.

3.3 Air Resources Board Commitments

As its part of the MOA, ARB committed to a number of tasks aimed at making California ready for the ZEV market. The following sections summarize the activities that the ARB has undertaken or supported to meet the commitments made in the MOA.

3.3.1 Purchase/Lease of EVs by State and Local Governments

The MOAs specify that ARB must facilitate the purchase of ZEVs for appropriate applications in state fleets. ARB must work with the California Department of General Services and the California Energy Commission to establish vehicle specifications for the State Bid List, and work with the Department of General Services Office of Fleet Administration to ensure the sale or lease of ZEVs to selected state agencies.

The Department of General Services has executed Master Service Agreements with the General Motors Acceptance Corporation (for the EV1 and the Chevrolet S-10), American Honda Motor Co., Inc. (for the EV PLUS), Toyota Motor Company (for the RAV4), and Ford Motor Credit (for the Ford Ranger). These Master Service Agreements allow all state agencies, as well as the University of California, California State University, the Community Colleges, and local governments, to lease ZEVs according to pre-defined and pre-approved terms, conditions and lease rates. This greatly simplifies the leasing process and allows for more rapid acquisition of vehicles. Additional Master Service Agreement with DaimlerChrysler Corporation (for the EPIC) and Nissan (for the Altra EV) are currently being developed.

As of February 2000, 25 different state and local agencies have leased or committed to lease more than 80 vehicles under these Master Service Agreements and prior agreements. These numbers are expanding rapidly due to the EV Sacramento program, discussed in Section 3.3.1.2 below. Leases or commitments have been made by the following:

- Department of General Services
- Department of Water Resources
- Department of Forestry and Fire Protection
- Department of Justice
- Department of Parks and Recreation
- Department of Food and Agriculture
- Department of Toxic Substances Control
- Department of Social Services
- Cal/EPA
- Air Resources Board
- Integrated Waste Management Board
- California Energy Commission
- California Highway Patrol
- CalTrans
- Bureau of Automotive Repair
- State Printer
- Franchise Tax Board
- California Exposition and State Fair
- University of California, Davis
- University of California, Los Angeles
- California State University, Chico
- Sacramento County
- City of Sacramento
- Sacramento Metropolitan Air Quality Management District
- Sacramento Metropolitan Airport

These totals do not include a large number of local agencies that have leased ZEVs using mechanisms other than the state Master Services Agreement.

The ARB and other state and local agencies have undertaken other activities to further encourage ZEV leasing, such as the following:

3.3.1.1 The EV Loan Program

To encourage the use of EVs in public fleets and address its obligation under the MOAs, the ARB designed a three-year program to loan EVs at no cost to federal, state and local government agencies. The South Coast Air Quality Management District provides financial support for the operation of the program within its jurisdiction. The Department of General Services (DGS) assists with housing, maintaining and dispatching the loan program EV fleet.

The goals of the EV Loan Program are to encourage EV leasing by providing public agencies with a no-risk opportunity to see if electric vehicles meet agency needs, familiarize senior officials with vehicle capabilities, and publicize the availability of electric vehicles to governmental agencies and to the public at large.

As of January 2000, the loan fleet includes fifteen vehicles--four GM EV1 vehicles with lead acid batteries, six Honda EV Plus vehicles with nickel metal hydride batteries, and five Ford Ranger pickups with nickel metal hydride batteries. Seven additional vehicles (two Chevrolet S10 pickups and five Toyota RAV4 vehicles, all with nickel metal hydride batteries) have been ordered to expand the program.

The EV Loan Program began operation on a pilot basis in Sacramento in March 1998, using one Honda EV Plus that was provided by the DGS. The loan program's own vehicles were delivered in June 1998 (EV Plus), August 1998 (EV1), and January 1999 (Ford Ranger). The program expanded to Los Angeles in September 1998, the Bay Area in October 1998, and San Diego in April 1999.

As of March 2000, there have been ninety-seven loans completed. Loan durations ranged from several days to three months, but the majority were one month. Seventeen loans are in progress, and twenty-two additional agencies are waiting to participate. Thirty-three vehicles have been leased as a result of the program, and several agencies are considering leases but have not yet made a final decision.

The EV Loan Program is a large-scale effort to provide public agency managers the opportunity to drive EVs. The program has demonstrated that public agencies, when given real-world experience with EVs, often find that the vehicles provide an environmentally sound way to meet many of their fleet needs. The agencies have been able to develop a good understanding of EV range, reliability, operating and maintenance costs, infrastructure requirements, and other data needed to make informed leasing decisions, both now and in the future.

3.3.1.2 Department of General Services Outreach

The Department of General Services, Office of Fleet Administration, has an aggressive program in place to encourage state agencies to lease electric vehicles. In addition to its support for the EV loan program described above, the Department:

- Provides free daily use of EVs through the state vehicle pool fleet
- Provides ride and drive opportunities to state executives
- Provides flexible lease terms with no-penalty cancellation provisions

- Sends letters to state fleet managers and Business Services Officers outlining EV availability
- Showcases EVs at numerous conferences and other events
- Participates in the national Clean Cities program
- Maintains a web site providing information on EV options

3.3.1.3 ev Sacramento

Many California public agencies are already using electric vehicles. EVs are being driven by agency administrators, field and technical staff, and have been incorporated into a variety of public programs. One barrier that has hindered public agencies in acquiring electric vehicles, however, has been their higher initial cost when compared to their conventionally fueled counterparts.

ARB is committed to increasing the use of electric vehicles by State agencies, and initiated **ev Sacramento** to assist with this commitment. The goal of **ev Sacramento** is to assist State and local public agencies in the Sacramento region to lease electric vehicles at competitive prices. By offsetting the initial higher costs of these vehicles, this program will significantly expand the use of electric vehicles in the Sacramento area.

The program is jointly administered by the ARB and the Department of General Services Office of Fleet Administration. **ev Sacramento** is a three-year program, and includes most of the electric vehicles that are now commercially available. The vehicles that are available through the program include the GM EV1, Toyota RAV4 EV, Ford Ranger, Chevy S10, and the Honda EV Plus. Program staff is also working with Nissan to include the Altra in the program. The majority of vehicles will be placed in the first and second quarter of 2000.

State and local agencies in the Sacramento area are eligible to participate. Participants pay reduced lease payments that are comparable to lease rates for conventional vehicles. In addition, **ev Sacramento** staff coordinate the delivery of the vehicles and the installation of charging infrastructure, and provide all training and user support.

As of February 2000, 13 state and local agencies have committed to lease 58 vehicles under the program, on target to an eventual goal of more than 100 vehicles.

3.3.1.4 State Budget Initiatives

Each year, the state Budget Act appropriates funds from the Petroleum Violation Escrow Account (PVEA) to support a variety of energy and transportation projects. Portions of this funding have been used to subsidize the purchase of electric vehicles and infrastructure by local agencies.

The 2000-2001 proposed Governor's Budget requests significant funding from the Petroleum Violation Escrow Account and the General Fund for electric and alternative fuel vehicles, incentives and infrastructure. Highlights include:

- \$5 million for the Air Resources Board to participate in the Fuel Cell Partnership
- \$6 million for the California Energy Commission to establish a clean fuels infrastructure for public agencies
- \$5 million for the California Energy Commission to establish the Vehicle Efficiency Incentive program to provide incentives for the lease or purchase of electric, hybrid electric, and fuel cell vehicles
- \$1 million for the California Energy Commission to develop a hydrogen fuel infrastructure as part of the Fuel Cell Partnership
- \$0.5 million for the California Energy Commission to study issues affecting hydrogen fueling infrastructure
- \$4 million for the Department of General Services to purchase alternative fuel vehicles for the state vehicle fleet

3.3.2 Insurance

The ARB is required to work with the California Department of Insurance to establish reasonable rates for insuring new ZEVs, to promote insurance industry awareness of ZEVs, and to resolve other issues related to insuring ZEVs.

ARB staff and Department of Insurance staff are not aware of any insurance issues that arisen with the market-based launch of EVs over three years ago. The EV user has had little difficulty obtaining necessary insurance. At least one manufacturer, Honda, includes comprehensive and collision insurance in the lease package. For drivers of other EV models, the insurance experience appears to have been smooth, with comparable coverage and rates available including second car discounts. On occasion, the EV user may need to spend additional time in the process if the insurer has not had experience writing a policy for an EV.

Based on an informal ARB staff survey of retail EV users in California, it appears that insurance for EVs is available from virtually every insurance company licensed to do business in California. Staff also met with a local insurance broker, who represents a larger company, to discuss the process for establishing the insurance rate for an EV. The broker indicated that the process is identical to that used for any vehicle on the market. With the make and model in hand, the broker looks up a vehicle's "insurance rating group" (IRG). Vehicles with similar characteristics, (e.g., replacement and repair costs, typical damage, and model year) may be placed in the same IRG. If a vehicle has not been assigned to an IRG, or is a new model or model year not covered by an IRG, the industry standard practice is to calculate a rate based on the manufacturer's suggested retail price (MSRP). The broker visited by staff had an IRG manual that contained specific instructions for EV rates to be calculated using the MSRP.

As no significant insurance issues have arisen with the market-based launch, ARB staff concludes that insurance issues will not present obstacles to further expansion of the EV market. Staff will, however, continue to monitor insurance availability for EVs as the market grows.

3.3.3 Financing

The ARB is required to work with the California Department of State Banking to develop risk assessment data to assist in securing financing for the purchase or lease of ZEVs.

To date, financing issues have not presented obstacles to further expansion of the EV market. Financing has not presented a problem for retail consumers because to date the vehicles are primarily leased rather than purchased. The decision to lease EVs to consumers rather than sell the vehicles has not been based on concerns about financing availability. Rather, the auto manufacturers have indicated that offering lease programs to consumers protects customers from risks associated with investing in new, quickly changing technology. ARB staff will continue to monitor these areas to ensure that any future issues that arise are dealt with in a timely manner.

3.3.4 Battery Recycling

The MOA directed the ARB to work with the Department of Toxic Substances Control, the Integrated Waste Management Board, and the Office of Environmental Health Hazard Assessment to ensure the availability of sufficient battery recycling capacity.

To address issues related to EV battery disposal and recycling, the ARB contracted with ARCADIS Geraghty & Miller in 1994. This contract work was broken into two main tasks. First, the contractor evaluated battery technologies based on their performance and recyclability. This work was completed in March of 1995. In addition to determining where efforts should be focused in establishing new recycling facilities and developing cleaner technologies, task one recommended that a deposit of between \$100 to \$150 be levied on light-duty vehicle batteries to ensure they are returned for recycling.

Task two compared the relative health and hazard impacts from EV battery recycling technology, and was completed in April of 1999. The main focus of task two was to compare the relative impact of recycling EV batteries in terms of cancer, toxicity, and ecotoxicological potential, as well as leachability, flammability, and corrosivity hazards. These impacts were evaluated for recycling methods, including smelting, electrowinning, and other appropriate techniques that apply to different battery technologies. A multi-attribute impact analysis was performed on the health and hazard effects resulting from the recycling and disposal of each battery type. The methodology used a semi-

qualitative ranking to weight the relative impact and establish a health and environmental impact score for each battery type.

Due to the substantial uncertainties surrounding the analyses, the methodology is designed for comparison purposes only. While current battery constituents are fairly well known, they do vary with manufacturer and are likely to change in the future. In addition, there are substantial uncertainties surrounding the health impact values and future recycling technologies. With this said, a broad conclusion of the analysis is that the more advanced batteries expected to be used in larger commercial quantities in the 2003 timeframe represent a great improvement over conventional lead-acid batteries, both in terms of battery performance and impacts from recycling spent batteries.

In addition to this contract work, ARB staff has also followed battery recycling issues at the national level by participating on the Department of Energy's Advanced Battery Readiness Working Committee. One of the Committee's main activities is to address issues related to EV battery disposal and to review progress made in developing new recycling methods for advanced batteries.

At this time, there do not appear to be any overwhelming obstacles to recycling the battery technologies expected in the 2003 timeframe. Currently, there is one facility in the United States capable of recycling nickel-based batteries. Another plant in Canada is now successfully recycling large military lithium-based batteries. While recycling technologies are being developed and are expected to be in place, it will be necessary to build new recycling plants for certain battery types, such as lithium-ion, to accommodate their use in large quantities. Any new recycling facilities would be required to meet stringent air quality and environmental regulations that would minimize any adverse effects of the recycling processes.

3.3.5 Assist Local Governments with Public Infrastructure

The MOA requires the ARB to work with local governments to provide assistance in planning and permitting quick charge and public charging stations. ARB has worked with utilities and electric vehicle infrastructure providers to assess charging station implementation issues and ensure that convenience-charging facilities are developed as needed. The California Energy Commission, ARB and other government agencies have also assisted with modification and adoption of electrical and building codes that address the needs of charging stations. This group instigated and coordinated the development of training for building officials involved with permitting and inspection of infrastructure installations.

The current status of public infrastructure is discussed in more detail in Section 6.2 below.

3.3.6 Training for Installation and Maintenance of EV Charging Stations

The MOAs directed ARB to work with utilities and trade groups representing electrical contractors to provide training for installation and maintenance of electric vehicle charging systems.

To address issues associated with installation of EV chargers, especially related to building codes, electrical codes and training of permitting and inspection personnel, the California Energy Commission formed the Building Codes Working Group. The Building Codes Working Group includes the Energy Commission, the ARB, the California Building Officials, the California Electric Transportation Coalition, California utilities, General Motors, and Hughes Power Systems. The Building Codes Working Group developed revisions to the California Building Standards to allow for safe installation of electric vehicle charging systems. The Building Code changes, effective in 1996, defined EV charging equipment, added safety requirements, clarified the definition of refueling, and added ventilation requirements. The Building Codes Working Group also modified the California Electric Code to include a requirement to use approved or UL listed EV charging equipment.

In an effort to provide a national standard for building code requirements related to EV charging systems, the Building Code Working Group focused much of its efforts through 1997 on preparing modifications to the National Electric Code. Changes suggested by the Building Code Working Group were forwarded to the National Infrastructure Working Council for approval and submittal to the National Electric Code governing organization.

Following adoption of the California code revisions, a training program was developed for building officials, which covered the following:

- The new Building Code and Electric Code provisions governing EVs;
- Plan check and inspection techniques for the new regulation;
- An overview of current and emerging EV technologies including automotive, batteries and charging equipment;
- An opportunity to see and drive current production vehicles; and
- Hands-on experience with charging system equipment.

Additional activities of the Building Code Working Group included development of Interim Disabled Access Guidelines for Electric Vehicle Charging Stations in cooperation with the State Architect. Since EV charging stations are offered as a service to the general public, they are required to be accessible to those with disabilities. The guidelines give potential public infrastructure providers guidance on making installations accessible to those with disabilities.

The final project undertaken by the Building Code Working Group was the development of an informational brochure for building officials, contractors and consumers. The brochure provides information about permitting and inspection

requirements, cites appropriate building and electric codes and gives phone numbers for agencies that can provide further information.

3.3.7 Support Efforts of National Infrastructure Working Council

ARB is required to support the Infrastructure Working Council's efforts on standardization of power supply, emergency disconnect, and standard conductive and inductive charging systems.

ARB staff has attended the Infrastructure Working Council's meetings, observing and participating in the Health and Safety Committee, the Connector and Connecting Stations Committee and the Connector Standardization Subcommittee of the Bus and Non-Road Committee. ARB's participation in the Health and Safety Committee has been focused on assistance with the proposed modification of the National Electric Code. ARB and California Energy Commission staff have observed and provided comments to the Connector and Connecting Stations Committee. This Committee, in turn, provided input to the Society of Automotive Engineers, which adopted a single standard for the butt-type conductive connector used by Honda and Ford. ARB staff has also observed the early work of the Bus and Non-Road Committee and has been asked to participate in the Connector Standardization Subcommittee as it works to determine the need for connector standardization for buses and non-road vehicles.

3.3.8 Training Programs for Emergency Response

ARB is required to work with the State Fire Marshal and other state and local emergency response officials and towing companies to create a comprehensive training program to ensure preparedness for incidents involving ZEVs.

Similar to the Building Code Working Group, the California Energy Commission formed the Emergency Response Working Group with ARB, the California Office of the State Fire Marshal, the California Highway Patrol, utilities, auto manufacturers and industry organizations such as the California Electric Transportation Coalition. The purpose of the working group was to develop training designed to inform emergency response personnel about EVs and the differences in response procedures for incidents involving EVs.

In 1998, the Emergency Response Working Group completed the development of a training program consisting of material to train instructors, an instructor's manual and compact disc, and slide teaching materials and student manuals. Train-the-trainer courses have been held throughout the state. Through the Infrastructure Working Council, the complete package of training materials has been distributed to every state Fire Marshal Office in the United States.

3.3.9 Observe Activities of the U.S. Advanced Battery Consortium (USABC)

The MOAs require ARB to maintain its commitment to observe the activities of the United States Advanced Battery Consortium (USABC) regarding the development of advanced technology batteries. The mission of the USABC is to pursue research and development of advanced energy systems capable of providing future generations of electric vehicles with significantly increased range and performance. The USABC has defined Mid-Term, Intermediate-Term ("Commercialization") and Long-Term criteria that set forth increasingly stringent goals for acceptable electric vehicle performance and economics. Now widely accepted as goals for ongoing development, these criteria are viewed by the USABC as the minimum standards that must be met if EVs are to be acceptable to a significant percentage of vehicle users.

Through the USABC, the three major U.S. vehicle manufacturers are committed to development of advanced batteries in keeping with their MOA obligation. ARB staff continues to attend the USABC Technical Advisory Committee (TAC) meetings on a quarterly basis. By attending these meetings, ARB staff is able to monitor the progress of USABC contracts with various developers and gain insight as to the contractors' progress. While much of the information obtained is confidential, the following provides a general overview of current USABC activities and developments.

The USABC completed its developmental efforts for Mid-Term battery technologies in 1999. The SAFT nickel-metal hydride (NiMH) and Ovonic Battery Company (OBC) NiMH technologies successfully demonstrated improvements in battery performance, cycle life, and cost reduction. For example, compared to the USABC Mid-Term goals of 80 Whr/kg, 150 W/kg, and 1,000 cycle life, both developers have achieved at least 70 Whr/kg, 150 W/kg, and 800 cycles. In fact, the SAFT technology has realized a cycle life well in excess of 1,000 cycles. OBC continues to make progress towards achieving a 100 Whr/kg EV battery design. For hybrid applications, where power is of greater importance than energy, OBC has achieved specific power levels surpassing 750 W/kg. While the cost of each NiMH technology is currently more than twice the USABC Mid-Term goal of \$150/Kwhr, both manufacturers have successfully reduced production cost by over 25 percent during the last two years.

Current USABC programs are focused on long-term battery technologies and meeting the USABC Long-Term and Commercialization goals. Two major contracts are currently in place investigating lithium-based battery technologies. The SAFT Lithium-Ion contract is currently in Phase I of the development process and is primarily focused on cell and module optimization. The Lithium-Polymer contract is also at the development phase with promise to offer a safe and cost effective battery technology within the next five years. These lithium-based technologies are expected to achieve specific energies well in excess of

100 Whr/kg. Improved specific power of greater than 200 W/kg and a cycle life of more than 600 are also expected. The key characteristic of battery cost should also benefit from these two technologies. It is currently forecast that both technologies should achieve cost goals of \$150-175/Kwhr at annual production levels of at least 20,000 battery packs.

The USABC is expected to initiate a Phase III program beginning in 2000. Phase III funding will be approximately \$62 million and span a total of four years. While it is unknown which technologies will be chosen for Phase III, USABC has indicated that only those technologies capable of realizing full-size packs under the contract will be considered.

3.3.10 Reasonable Incentives

Under the MOAs, ARB must support the development and implementation of reasonable incentive programs that enhance the near-term marketability of ZEVs. Because ZEVs are a relatively new technology and are currently produced in limited quantities, they are more expensive than conventional vehicles. To enhance vehicle marketability in the near term and to assist in the transition to large volume production, it is vital to provide support, both monetary and non-monetary, in the form of vehicle and infrastructure incentives.

Where possible, the ARB and other state agencies have supported the development and implementation of various incentive programs. The California Energy Commission has continued to support vehicle buy-down programs at the district level and has recently provided matching funds for the development of EV infrastructure. Recent legislation authored by Assembly Member Cuneen and signed by Governor Davis allows single occupant vehicles with "inherently low emissions" (ZEVs, as well as vehicles using alternative fuels, with extremely low tailpipe emissions and zero evaporative emissions) to use high occupancy vehicle lanes.

The following list provides an example of the federal, state, local and private incentive programs currently available.

3.3.10.1 Federal Incentives

- Tax credit for 10 percent of the cost of an EV, up to \$4,000, through 2004.
- Business tax deduction of \$100,000 for electric recharging sites.
- The Energy Policy Act of 1992 includes a ten year \$50 million EV demonstration program and a fifteen year \$40 million cooperative program between government and industry to research, develop and demonstrate EV infrastructure.
- Elimination of the luxury tax for alternative-fueled vehicles.

3.3.10.2 State of California Incentives

- Up to \$5,000 of the incremental cost of a ZEV for fleets located in Clean Cities (Bay Area, Orange, Riverside, Sacramento, San Bernardino, San Diego, Santa Barbara, Ventura and Yolo-Solano) provided by California Energy Commission and the U. S. Department of Energy.
- CEC funds support the installation of EV charging infrastructure by new purchaser or lessee.
- PVEA funds are made available to local governments to support the lease of alternative fuel vehicles.

3.3.10.3 Local Incentives

- The Mobile Source Reduction Committee of the South Coast Air Quality Management District offers public and private customers a \$5,000 rebate per EV purchased or leased.
- In conjunction with the CEC, several Air Pollution Control Districts offer \$5,000 for the purchase or lease of EVs for public and private customers.
- The Los Angeles Airport offers free parking and charging for EVs in its Central Terminal Area. Charging stations were installed at the Los Angeles Airports as part of the Quick Charge Los Angeles EV program.
- The City of Sacramento offers free EV parking and charging at city garages.

3.3.10.4 Utility Incentives

- The Los Angeles Department of Water and Power, Sacramento Municipal Utility District, and Southern California Edison all provide discounts for off-peak recharging of EVs to retail EV customers. These discounts typically result in at least a fifty percent reduction in the cost of charging, with rates around 5 cents per kilowatt-hour.
- San Diego Gas and Electric offers a discount rate for electricity used to recharge EVs during off-peak time periods as well as \$50,000 in seed money to help local businesses and governments install charging stations in its service area.

In addition to these incentives, the ARB has been working cooperatively with government agencies, auto manufacturers and other stakeholders to determine the most effective way to support the introduction of ZEVs into the marketplace. New monetary as well as non-monetary incentives have been discussed in addition to possible extensions of the incentives that currently exist. Many of these existing incentives were put into place prior to the 1996 amendments to the ZEV program and it would be appropriate to extend them to foster the commercialization of ZEVs during the market-based introductory period.

3.4 Additional ARB Activities

ARB has instigated or been involved in a number of outreach programs, events and research contracts in addition to those addressed in the MOAs. Board members and staff have participated in local outreach as well as attended conferences and exhibitions promoting the use of zero-emission vehicles.

3.4.1 ARB Test Fleet

The ARB has acquired a test fleet of EVs, with three GM S-10s, three GM EV1s, and two Honda EV PLUS vehicles. In an effort to gather information about the vehicles, their usage patterns, and issues associated with everyday EV use, ARB has set up a system to allow ARB employees to use the vehicles for between two days and a week. Employees are encouraged to do outreach to schools and other local groups. Participating employees are given a specific vehicle to drive for a week or a weekend and are encouraged to use the vehicle for as much of their normal driving as possible. Employees are then required to fill out a log that indicates usage pattern and any suggestions regarding vehicle usability and accessibility. This system has been very successful and gives ARB and users the opportunity to gain valuable experience with EVs and infrastructure. Based on discussions with employees and entries in the EV logbooks, these experiences are typically very positive and users find that the vehicle meets practically all their driving needs. (insert number of outreach events when compiled)

3.4.2 EV Rental Demonstration Program

The ARB and the South Coast Air Quality Management District (SCAQMD) are working together to support an electric vehicle rental demonstration program. This program will provide high visibility and convenient availability of EVs. The EV Rental Demonstration has the following objectives:

- Establish a successful EV rental program that will give a large number of the general public and government employees the opportunity to experience the benefits and attributes of EVs.
- Provide positive image of EVs for public and policy makers.
- Gain valuable information regarding the use of EVs in rental car fleets.
- Provide clean air benefits in those areas renting the EVs.

EV Rental Cars L.L.C. was chosen through a competitive bidding process to conduct the EV Rental Demonstration program. EV Rental Cars is working jointly with Budget Rent-a-Car to rent EVs. In addition to the Los Angeles International Airport location, which opened in December 1998, and the Sacramento International Airport location, which opened in August 1999, the program will expand to five additional Budget Rent-a-Car locations:

- Burbank Airport
- John Wayne Airport in Orange County
- Ontario International Airport
- Downtown Sacramento
- Beverly Hills

The ARB is providing \$100,000 to co-fund this program and 5 Honda EV Plus vehicles. The SCAQMD is providing \$200,000. In addition, EV Rental Cars and the other subcontractors involved in the program will cost-share by contributing \$252,000 in cash and \$523,755 in-kind to this project. These subcontractors include SMUD, the City of Burbank, the City of Anaheim, the Los Angeles Department of Water and Power, and Southern California Edison.

3.4.3 EV Long-Term Placement Program

The Honda Motor Company provided funding for Supplemental Emission Projects, as part of a Settlement Decree with ARB. The Supplemental Emission Projects include the Electric Vehicle Long Term Placement Program, under which 25 Honda EV Plus electric vehicles have been made available to public agencies for long-term loans (6 months to one year). The goals of the Electric Vehicle Long Term Placement Program are to promote greater awareness of electric vehicles among the public, familiarize senior public and private officials with electric vehicles and their capabilities, and encourage the leasing of electric vehicles by public agencies.

The Electric Vehicle Long Term Placement Program is a three-year program, now in its first year of operation. Vehicles have been placed with a variety of public agencies:

- Yosemite National Park (2 vehicles)
- State Parks in Sacramento and San Diego (1 vehicle each)
- Griffith Park, Los Angeles
- San Joaquin Valley Air Quality Management District
- Sacramento Metropolitan Air Quality Management District
- Ventura County Air Pollution Control District
- Yolo-Solano Air Pollution Control District
- Resources Agency Secretary
- Trade and Commerce Agency Secretary
- EV Loan Program, Bay Area (2 vehicles) and San Diego (1 vehicle)
- DGS State Garage Daily Rental
- ARB vehicle fleet (4 vehicles)
- EV Rental Fleet (5 vehicles)

Agencies that have received vehicles will provide a brief report at the end of the placement. The report will summarize the accomplishments of the program,

identify activities in which the vehicle was used, and note any problems that occurred. This data will provide on-going information by which to evaluate the effectiveness of the program, as well as track any vehicle or charging problems that may have occurred. After agencies have concluded their loans, ARB staff will solicit new participants for the program.

3.4.4 Participation in Conferences and Exhibitions

ARB has participated in a number of conferences and exhibitions including the North American Electric Vehicle Infrastructure Conference, several international Electric Vehicle Symposia, the World Electric Vehicle Expo, the Los Angeles International Auto Show, and various Clean Cities Conferences. ARB has attended, contributed papers and/or purchased booth space at these and other gatherings. In addition, Board members and staff have participated in ride and drive programs, public relations events and technical advisory groups.

3.4.5 Outreach Events

Board members and staff have been very proactive in conducting public outreach to schools, community events, and community groups. These outreach events have been very successful at a "grass-roots" level. Often, a Board or staff member is accompanied by a member of the Zero-Emission Vehicle Implementation Section who may give a presentation or participate in a demonstration of the vehicle.

Over the past twelve months, ARB staff using vehicles from the ARB test fleet have participated in thirty-four outreach events at schools and more than twenty other events at youth groups, fairs, Earth Day celebrations, and other similar locations. Over the same time period staff from the ZEV implementation Section participated in an additional sixteen events including Science Day at the State Capitol, Clean Air Day, and the Los Angeles International Auto Show. These events provide participants with an opportunity to gain experience with new vehicle technology and have questions answered about EV capabilities.

4 VEHICLE TECHNOLOGY ASSESSMENT

4.1 Introduction

In June 1999, ARB began meeting with auto manufacturers to discuss their obligations and plans for meeting the ZEV requirement in MY 2003. In December 1999 and February 2000, ARB staff visited all the large volume manufacturers in Japan and in the US to examine, first hand, the progress each manufacturer is making in preparing to meet the ZEV requirement as detailed in their product plans. Prior to the site visits, each manufacturer had provided ARB staff with product plans describing in detail how they intend to meet the MY 2003 ZEV requirement. The product plans included information regarding key development stages, decision points, and other milestones. In addition, the site visits provided ARB staff with a chance to examine prototypes of various types of advanced vehicle technologies.

This chapter discusses the development status of “pure” zero emission vehicles, and “full” and “partial” ZEV allowance vehicles. It concludes with a discussion of new categories of vehicles such as city and neighborhood electric vehicles. These latter vehicles are discussed separately because they have different operating characteristics than full range vehicles and are intended to fill different market segments.

4.2 Pure ZEV Vehicles

This section evaluates the progress made to date in developing “pure” zero-emission vehicles--vehicles having no direct emissions. Vehicles can be certified as ZEVs if they produce zero exhaust emissions of any criteria pollutant (or precursor pollutant) under any and all possible operational modes and conditions. These vehicles do, of course, result in a small amount of indirect emissions at stationary sources such as power plants or hydrogen production facilities due to the generation of electricity or hydrogen for use on board the vehicle. In the discussion of vehicle emissions (Section 9) the indirect emissions and environmental impacts from these stationary sources will be quantified in order to allow a meaningful comparison to other vehicle technologies.

Pure zero-emission vehicles hold distinct air quality advantages over technologies that use a conventional fuel such as gasoline in a combustion engine. Vehicles with combustion engines inevitably exhibit deterioration that results in increased emission levels as the vehicle ages. They are also subject to becoming gross polluters if critical emission control systems fail. High volatility liquid fuels such as gasoline are responsible for significant fuel cycle emissions. For all of these reasons, vehicles with no potential to produce emissions are the “gold standard” of even the cleanest, most advanced new technologies.

From the inception of the ZEV program, the battery electric vehicle has been the leading candidate for meeting the ZEV percentage requirements due to its stage of commercial development. Since 1990, worldwide effort in the research and development of vehicle and battery technology has greatly improved the prospects for the successful commercialization of electric vehicles. More recently, fuel cell technology has gained worldwide attention as a technology capable of supplanting current internal combustion engine vehicles in the market while providing zero direct emissions (when using stored hydrogen). The following sections provide a summary of the developmental status and infrastructure needs for these two technologies.

4.2.1 Battery Electric Vehicles

Battery electric vehicles were first commercialized more than one hundred years ago. After giving way to gasoline vehicles in the first part of this century, several efforts were made in the 1960's and 1970's to reintroduce and commercialize the technology. While the basic concept of today's electric vehicle remains the same, significant advances in components and vehicle technology have provided new opportunities for the use of electric drive in passenger vehicles.

4.2.1.1 Description of Technology

Battery electric vehicles use an electrochemical battery to store energy. In addition to this energy source, an electric vehicle employs an electric powertrain that includes a motor and controller. Electric vehicles use one of three different types of electric motors: DC (both series and shunt), AC-induction, and permanent magnet DC-brushless. Controllers used with these motors are usually either solid-state electronic, pulsed-width modulation with power transistors, or insulated gate bipolar transistors. Other components include the battery management system, battery charger, state-of-charge meter, charging connector, and electronic protection devices.

4.2.1.2 Development Status

Historically, the inability of batteries to store sufficient energy at a reasonable cost has limited the market for battery electric vehicles. However, considerable advances in the last ten years in component technology have greatly improved overall vehicle efficiency and thus range. By improving the efficiency of drivetrain components and integrating the operation of the battery and drive train under normal operating conditions, EVs currently available can deliver nearly three times the range of EVs from the 1970's having the same amount of stored energy. Just as important, these advances have also included new designs that are projected to be cost comparable to the internal combustion engine vehicle in large volume production (not including the battery). The improved efficiency has been achieved in large part due to the improvements in efficiency of each

component mentioned above and through the integrated operation of battery and drivetrain under normal vehicle operating conditions.

The production status of battery electric vehicles from the major manufacturers is discussed under Section 2.5 above.

Because battery technology is the critical component in a battery electric vehicle, the ARB has contracted with four experts in battery technology to closely evaluate the state of development and cost issues of advanced batteries. The results of the expert study will be made available when their work is complete. A preliminary draft report is scheduled to be available prior to the May 2000 workshop.

4.2.2 Fuel Cell Vehicles

Fuel cells are electrochemical devices that allow for the conversion of chemical energy of fuels directly into electricity. By doing so, the technology avoids the loss of efficiency and emissions of air pollutants that occur with the use of combustion-based engines. While originally discovered in 1839, the first practical use of the technology occurred during the early years of the manned space program in the 1960's. Subsequent manned space efforts, up to and including the Space Shuttle program, have continued to rely upon fuel cells for electric power. This success, in turn, has resulted in large efforts and investments in the technology to develop fuel cell technology for both stationary and mobile applications.

More focused efforts to develop the technology for transportation have resulted in significant improvements in the core technology. The key motivations for this recent interest include concern over urban pollution, a need for alternatives to a diminishing oil supply, and growing concern over global climate change due to carbon dioxide emissions from mobile sources. Because fuel cells are powered by alternative fuels, and operate at high efficiency, fuel cell vehicles can help achieve both energy efficiency and energy diversity goals. A fuel cell vehicle can either store hydrogen or obtain hydrogen through the reformation of an alternative fuel.

4.2.2.1 Description of Technology

While there are several different fuel cell technologies available for use in vehicles, the leading candidate for automotive application is the proton exchange membrane (PEM). Simply described, a fuel cell consists of a membrane, two electrodes, and gas chambers. In acid electrolyte, hydrogen reacts at the electrode, giving up electrons while hydrogen ions are passed through the electrolyte. The electrons are used to operate an electric motor that can then propel the vehicle. After transferring to the cathode side, the hydrogen ions combine with oxygen, and the electrons that have produced work, to form water.

Since no combustion is involved, water is the only product from the process. Many of the same components needed by a battery electric vehicle (e.g. the electric power train) are also necessary in a fuel cell electric vehicle.

4.2.2.2 Development Status

In 1998, the ARB contracted with a Panel of experts in fuel cell technology to assess the current status of fuel cells for transportation applications. According to the Panel's review of the technology, significant advances in fuel cell stack technology in recent years have overcome the technical barriers to attaining the performance needed for fuel cell electric vehicle engines. Efforts are now ongoing worldwide to integrate the latest fuel cell designs into fuel cell engines, and ultimately fuel cell electric vehicles.

While much work needs to be done to successfully integrate fuel cell technology into vehicles, the Panel found no fundamental barriers to their commercialization. The report went on to note that "in a complete success scenario, fuel cell electric engines and vehicles could become commercially available from two or three automobile manufacturers beginning in 2004/2005." The biggest challenge now facing automakers is to package the necessary hardware and reduce the cost of the technology to a level comparable to the internal combustion engine.

Since the release of the Fuel Cell Panel report in 1998, manufacturers have continued to advance the state of the technology. For example, recent news reports have described:

- Significant improvement in fuel cell stack performance under freezing conditions
- Development of next generation stacks that provide higher power while reducing system size and weight
- Introduction of new prototype vehicles by DaimlerChrysler, Ford (Th!nk) and General Motors
- Development of advanced fuel system technologies

The availability projection noted above applies to for fuel cell vehicles that reform (or extract hydrogen from) a fuel such as methanol on board the vehicle. The operation of a reformer, however, results in ozone precursor emissions. Thus, to achieve zero direct emissions the vehicle has to store hydrogen on board the vehicle. While this greatly simplifies the vehicle's design (e.g. no reformer), it raises new issues regarding the storage of sufficient quantities of hydrogen on the vehicle. The storage of hydrogen, even at fairly high compression (e.g. 5,000 psi), requires roughly 10 times the volume that is needed for the storage of an equivalent amount of energy in gasoline form. Because the fuel efficiency of a fuel cell is significantly higher than that of an internal combustion engine, less fuel is needed to go a given distance. Nevertheless, passenger cars are not

currently able to accommodate enough hydrogen for adequate range without seriously compromising the passenger and cargo space.

Manufacturers have explored options that include storing the hydrogen in low-temperature liquid form, or bound chemically to a metal alloy. Efforts continue, but the potential for breakthroughs in hydrogen storage remains uncertain. While a hydrogen fuel cell vehicle is believed to be the best long-term approach, its commercial introduction is not expected in the next five years. As part of research and development of fuel cell vehicles, automakers will demonstrate passenger cars using stored hydrogen in liquid form. The goal is not to demonstrate the commercial feasibility of this design, but rather to test, evaluate and refine all aspects of the fuel cell stack and engine.

To address fuel cell vehicle and infrastructure issues, in April 1999 California Governor Gray Davis and industry leaders announced a fuel cell vehicle partnership that will demonstrate clean transportation technology on California's roadways in the future. The "California Fuel Cell Partnership - Driving the Future" makes the state home to a unique collaboration of auto manufacturers (DaimlerChrysler, Ford, Honda, Nissan, Volkswagen), energy providers (ARCO, Shell, Texaco), a fuel cell company (Ballard Power Systems), the State of California (Air Resources Board, California Energy Commission), and the United States Department of Energy.

Associate partners, who bring specific expertise to aid in fuel, vehicle and bus demonstration activities, include Air Products and Chemicals, Inc., Linde AG, Praxair, Methanex, the Alameda-Contra Costa Transit District, and the SunLine Transit Agency.

The Partnership will demonstrate fuel cell powered electric vehicles under real day-to-day driving conditions. The Partnership will place about 50 fuel cell passenger cars and fuel cell buses on the road between 2000 and 2003.

4.3 Full and Partial ZEV Allowance Vehicles

In 1998 the ARB modified the ZEV requirement to allow ZEV credit to be earned by vehicles with near-zero emissions. This section discusses the development status of such vehicles.

4.3.1 Definitions and Requirements

Under LEV II, "near-zero" emission vehicles may qualify to earn a ZEV allowance of between 0.2 and 1.0 per vehicle. Vehicles that qualify for a ZEV allowance of 1.0 are known as full ZEV allowance vehicles. Vehicles that qualify for a ZEV allowance of between 0.2 and 1.0 are known as partial ZEV allowance vehicles (PZEVs). Staff believes that this ZEV allowance approach towards satisfying the ZEV requirement will promote the continued development of battery-powered

electric and zero-emitting fuel cell vehicles, while encouraging the development of other advanced technology vehicles that have the potential for producing extremely low emissions. Manufacturers will be able to decide which mix of vehicles makes the most technological and economic sense based on their own strengths in each area.

Large automakers must meet at least 40 percent of their ZEV requirement with pure ZEVs, full ZEV allowance vehicles, or credits generated by either of these vehicle types. They may meet the remaining 60 percent of their overall ZEV requirement with PZEV vehicles earning ZEV allowances of less than one.

To earn a ZEV allowance for a vehicle, the manufacturer must, at a minimum, meet the following baseline PZEV requirements:

- Certify vehicle to 150,000 mile SULEV emission standards
- Certify vehicle to zero evaporative emission standards
- Certify vehicle to meet OBD II requirements for the life of the vehicle, and
- Extend performance and defects warranty to 15 years/ 150,000 miles

One important advantage of battery and hydrogen fuel cell electric vehicles is that their “tailpipe” emissions do not increase when their components fail and are in need of repair. The extended warranty requirement for PZEVs is a very important element of LEV II and is intended to address this issue. It requires manufacturers to provide a 150,000 mile emission warranty under which all malfunctions identified by the vehicle’s OBD II system will be repaired under warranty for a period of 15 years or 150,000 miles (whichever occurs first). This warranty is necessary to ensure that vehicles receiving credit for near zero emissions are able to maintain this performance throughout the useful life of the vehicle, as is the case with pure ZEVs.

Vehicles that meet all of these minimum or “baseline” requirements earn a 0.2 PZEV allowance. Since ARB regulations do not specify particular fuel or propulsion technologies, there is a wide variety of potential vehicle fuel and drive system combinations that may qualify for PZEV allowance in the coming years. The overall ZEV allowance assigned to a vehicle is the sum of 3 individual assessments:

- | | |
|--|------------|
| • Baseline (minimum) PZEV allowance | 0.2 |
| • Zero emission vehicle miles traveled (VMT) allowance or Advanced Componentry | 0.0 to 0.6 |
| • Low fuel cycle emissions allowance | 0.0 to 0.2 |

Table 4-1 on the next page lists a number of existing and hypothetical vehicle types, along with estimates of the maximum potential ZEV allowance they might be eligible to earn:

Vehicle Type (Must meet all PZEV requirements)	Primary Energy Source	Secondary Energy Source	Zero Emission Range (miles)	PZEV Baseline Allowance	Zero- Emission VMT Allowance	Low Fuel Cycle Emissions Allowance	Total ZEV Allowance
Gasoline ICE	Gasoline	N/A	0	.2	0	0	.2
Gasoline ICE / HEV	Gasoline	Electricity	0	.2	.1 (components)	0	.3
CNG ICE	CNG	N/A	0	.2	0	.2	.4
LFCE ICE HEV, 0 mile ZE range	CNG, methanol, hydrogen	Electricity	0	.2	.1 (components)	.2	.5
Gasoline ICE HEV, 20 mile ZE range	Grid Electricity	Gasoline	20	.2	.3 + .1 (max off-vehicle charging)	.1	.7
Hydrogen ICE	Hydrogen	N/A	0	.2	.3 (0 NMOG)	.2	.7
Methanol Reformer FCV	Methanol	Electricity	0	.2	.3 (0 NOx)	.2	.7
Gasoline ICE HEV, 40 mile ZE range	Grid Electricity	Gasoline	40	.2	.4 + .1 (max off-vehicle charging)	.16	.8
LFCE ICE HEV, 20 mile ZE range	Grid Electricity	CNG, Methanol, etc.	20	.2	.3+.1 (max off-vehicle charging)	.2	.8
LFCE ICE HEV, 40 mile ZE range	Grid Electricity	CNG, Methanol, etc.	40	.2	.4 + .1 (max off-vehicle charging)	.2	.9
LFCE ICE HEV, 73 mile ZE range	Grid Electricity	CNG, Methanol, etc.	73	.2	.5+.1 (max off-vehicle charging)	.2	1.0
Gasoline HEV, 100 mile ZE range	Grid Electricity	Gasoline	100	.2	.6	.2	1.0
Hydrogen ICE HEV, 20 mile ZE range	Grid Electricity or H2 with FC APU	Hydrogen	20	.2	.3 +.3 (0 NMOG)	.2	1.0
Direct Methanol FCV	Methanol	Electricity	Any				ZEV
Battery EV	Grid Electricity		Any				ZEV
Stored Hydrogen FCV	Hydrogen		Any				ZEV

Abbreviations used in the table are:

CNG: Compressed natural gas
FCV : Fuel cell vehicle
HEV: Hybrid electric vehicle
ICE: Internal combustion engine
LFCE: Low fuel cycle emissions
PZEV Partial Zero Emission Vehicle
SULEV Super Ultra Low Emission Vehicle
VMT: Vehicle miles traveled
ZE Range: Zero-emission range

It should be emphasized that the LEV II regulations do not establish specific ZEV allowances to be earned with particular fuel or propulsion technology choices. Rather, allowances are earned according to the three factors noted above, and depend on the actual performance achieved by a vehicle with a particular fuel and propulsion technology. The examples in the table below indicate staff's current assessment of the maximum achievable allowances possible for the vehicle types shown.

4.3.2 PZEV Availability

The following section outlines current information regarding the availability of production PZEVs, today and in the future (2003 and beyond).

4.3.2.1 MY 2000 PZEVs Presently Available

At the present time, only the Nissan Sentra 'CA' ("Clean Air") has achieved California certification for PZEV credit. Staff does not anticipate any further applications for PZEV certification for MY 2000 vehicles.

Nissan Sentra CA (Gasoline SULEV, PZEV Credit =.2)

Make	Model	Emissions Class	City/ Hwy EPA MPG	Primary Energy	Secondary Energy	Primary Propulsion	Secondary Propulsion
Nissan	CA	PZEV-.2 (SULEV)	26/ 33	Gasoline	N/A	Gasoline ICE	N/A

The 2000 model year Nissan Sentra CA is the first vehicle to be ARB-certified to meet SULEV requirements as well as the additional warranty and evaporative emissions controls necessary to achieve a baseline PZEV rating. Several key technologies allow the Sentra CA to achieve PZEV performance levels. These include:

- Double-wall exhaust manifolds,
- Quicker warm-up catalyst
- A new combustion control sensor, and

- An electronically controlled swirl control valve that reduces hydrocarbon emissions in both cold and warm start situations.

In addition, the radiators of all Sentra CAs are coated with Engelhard Corp.'s PremAir® coating, which converts ozone entering the radiator into oxygen.

The Sentra CA will be a limited production vehicle. Sales of the Sentra CA are scheduled to begin in March 2000 in California.

4.3.2.2 MY 2000 SULEVs Not Qualifying For PZEV Credit

In addition to the Nissan Sentra CA, two other MY 2000 vehicles have met certification requirements for the SULEV standard. These vehicles will not earn PZEV allowances, however, because they do not yet meet all of the minimum baseline requirements necessary for PZEV status.

The MY 2000 Honda Accord SE has been certified to SULEV emissions standards, but has not been certified to attain PZEV allowance requirements for durability, warranty, or zero evaporative emissions at this time. The Accord SE would be eligible for a 0.2 ZEV allowance if the additional PZEV requirements were to be met.

The MY 2000 Honda Civic GX is a CNG fueled ICE vehicle that is ARB certified as a SULEV and already meets zero evaporation requirements. It does not yet offer the enhanced 150,000-mile emissions warranty required for PZEV baseline certification. Honda states that they do not yet have sufficient durability data on this vehicle to justify the warranty extension necessary for PZEV certification. Since CNG fueled SULEVs that qualify for a PZEV baseline allowance of 0.2 would also be eligible to receive 0.2 allowance for low fuel cycle emissions, the Civic GX could someday qualify for a 0.4 PZEV allowance.

Make	Model	Emissions Class	City/ Hwy EPA MPG	Primary Energy	Secondary Energy	Primary Propulsion	Secondary Propulsion
Honda	Accord SE	SULEV	23/20	Gasoline	N/A	Gasoline ICE	N/A
Honda	Civic GX	SULEV	28/34 (equivalent)	CNG	N/A	CNG ICE	N/A

4.3.2.3 Other Production Vehicles With Some PZEV Characteristics

The Toyota Prius is the first modern-day HEV to be offered for sale. As of January 2000, Toyota has delivered more than 30,000 units to customers in Japan. Toyota has announced its intent to certify the MY 2000 Prius HEV to SULEV standards, but is not expected to apply for certification to PZEV levels. Although the current Prius HEV is capable of traveling very short distances in ZEV mode, it cannot yet attain the minimum 20-mile all electric range necessary to earn a zero-emission range allowance.

If future versions of the Prius or similar gasoline HEVs with negligible zero emissions range meet PZEV zero evaporative emission requirements, they would attain an overall PZEV allowance of 0.2 baseline plus 0.1 for advanced electric drivetrain componentry, for a total PZEV allowance of 0.3.

The Honda Insight is the first modern-day HEV to be offered to customers in California. It is currently certified at ULEV emissions level, so it cannot yet qualify for a PZEV baseline allowance. The Insight HEV design emphasis is on high efficiency, and hybridization enables it to achieve the highest mileage and consequently the lowest CO₂ emissions of any gasoline-powered passenger car available in the United States.

While the Toyota Prius lacks only a larger battery and a charging port to achieve significant zero-emissions range, the present design of the Honda Insight powerplant links the electric motor directly to the engine and prevents attainment of any motor-only, zero-emission operation.

Make	Model	Emissions Class	City/ Hwy EPA MPG	Primary Energy	Secondary Energy	Primary Propulsion	Secondary Propulsion
Toyota	(Prius) U.S. Model name TBD	SULEV (target)	(TBD)	Gasoline	Electricity: 1.8 kWh total energy, ~.18 kWh useful energy	Gasoline ICE, (~43 kW)	Electric Motor, (~30 kW)
Honda	Insight	ULEV	61/70	Gasoline	Electric ~.9 kWh total, ~.09 kWh useful	Gasoline ICE (54 kW)	Electric (10 kW)

4.3.2.4 Other Power-Assist HEVs

Staff expects several additional “power-assist” parallel HEVs to become available before 2004. These HEVs are also expected to be equipped with relatively small motors with less than 25 percent of engine power capability, and very small battery packs (less than 2 kWh). Although these power-assist HEVs are designed primarily to improve fuel economy and do not necessarily reduce criteria emissions, they can significantly reduce CO₂ emissions. Sales of “power assist” HEVs would also require manufacturers to increase their design and production capability for motors, inverters, and battery packs, which may be used in other types of electric-propulsion vehicles.

4.3.2.5 PZEV Availability in MY 2003 and Beyond

Under the ZEV regulation, intermediate manufacturers may meet their entire ZEV obligation using PZEVs, and major manufacturers may meet 60 percent of their ZEV obligation. Other than the Nissan Sentra CA, discussed above, no manufacturer has announced definitive plans to market PZEVs in MY 2003.

Manufacturers have indicated that the most difficult challenges to be met for PZEV certification are the zero evaporative emission level and the 150,000-mile emissions warranty. In addition, the timing of PZEV introduction likely will be affected by manufacturer-specific external cycles such as the planned retirement date for engine families and their replacement by new engines. Staff anticipates, however, that additional PZEV models will be announced prior to 2003.

4.3.3 All Electric Range and Efficiency Improvement

Both battery EVs and hybrid electric vehicles with zero-emission range that are able to charge from the electric grid can achieve high efficiency along with extremely low emissions. Typical battery EVs achieving 250-500 Whr/mile (AC) are also demonstrating an efficiency equivalency of 77-154 MPG (assuming energy content of gasoline is 38.6 kWh/gal). This high energy efficiency results in correspondingly low CO₂ emissions. Although vehicle operating efficiency and CO₂ emissions are not regulated by the ARB, staff recognizes that inefficient vehicles require more costly and complex systems to control criteria emissions. In addition, a malfunctioning low-efficiency gasoline vehicle operating up to 2 years between smog inspections has the potential to emit many times more emissions than a faulty high-efficiency vehicle.

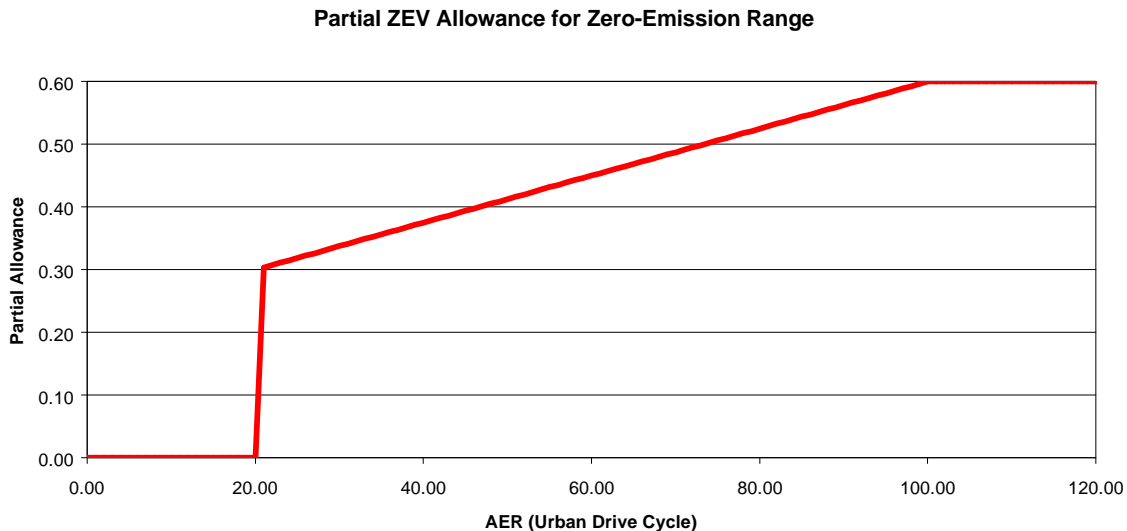
4.3.4 Partnership for a New Generation of Vehicles

The Partnership for a New Generation of Vehicles (PNGV) is a collaboration between the United States Government and the major domestic automakers. The long-term goal of the PNGV is to develop vehicles that will deliver up to three times today's fuel efficiency (80 miles per gallon) and cost no more to own and operate than today's comparable vehicles. At the same time, this new generation of vehicles should maintain the size, utility and performance standards of today's vehicles.

The PNGV program near-term development emphasis has been on diesel-powered vehicles, because its goals are narrowly focused on fuel efficiency. The Partnership has, however, also funded developments that may have significant impact on future emissions reductions. Program contractors have developed improvements in lightweight materials, high-power batteries, fuel cell components, and reductions in vehicle road-load. For example, a recent PNGV-funded prototype announcement for the GM Precept discloses an extremely low aerodynamic drag coefficient of .163, which is less than one-half of the drag exhibited by a typical modern car. The ability of auto manufacturers to reduce aerodynamic drag to these extraordinarily low values will substantially reduce the power and energy storage requirements of future ZEVs and PZEVs, and may accelerate the introduction of cost-effective near-zero or zero emission vehicles.

4.3.4 HEVs With Significant Zero Emission Range

Three PZEV allowances are added together to determine a vehicle's overall allowance. One of these three, the zero-emission VMT allowance, is based on the potential for realizing zero-emission vehicle miles traveled, and is determined as shown in the graph below.



During the development of LEV II, ARB staff believed that manufacturers would develop HEVs with battery packs that were smaller and less expensive than those needed for battery EVs, but still big enough to provide significant ZEV range and to justify recharging from the electric grid. These smaller packs for HEVs might have an energy storage capacity as low as 10-15 kWh instead of 30+ kWh in battery EVs, but would be sufficient to enable vehicles to attain a relatively large ZEV VMT allowance. Based on public announcements to date, however, staff does not believe that grid-charged hybrid electric capability will be made available on any MY 2000-2003 vehicles. The only hybrid electric vehicles expected during this time will probably be equipped with very small battery packs of less than 2 kWh capacity that are charged from gasoline-derived energy only. While LEV II was written to encourage vehicles with zero-emissions range like grid-connected HEVs because of their low emissions, high efficiency, and other ZEV-like attributes, it is unlikely that manufacturers will make use of this option to achieve higher PZEV allowances for zero-emission range before 2004.

Automotive manufacturers and researchers have, however, developed and demonstrated several prototype HEVs that demonstrate significant zero-emission range and are able to charge their battery packs with grid-supplied electricity. No manufacturer has announced when these types of HEVs will become available, and most cite the same primary obstacle claimed for the slow introduction of BEVs--high battery cost. Although many of these advanced prototypes would not yet meet ARB's SULEV requirements, with further engine refinement to SULEV

standards they would achieve very high PZEV credits because of their ZEV range capability.

Examples of functional prototype and demonstration “grid connected” hybrid vehicles include:

- Several GM EV-1 based show cars,
- GM Triax,
- DOE/ SAE Futurecar and Futuretruck Student-competition HEVs,
- Suzuki EV Sport,
- Volvo HEV,
- Ovonic-Modified (grid connected) Toyota Prius,
- Audi Duo.

4.4 On-Road Neighborhood and City Electric Vehicles

Several classes of small on-road electric vehicles have begun to emerge in the last few years that will displace gasoline vehicle usage and increase overall zero-emission miles traveled within California. These vehicles are under consideration because they offer a number of desirable characteristics:

- Very high efficiency
- Affordable to build, and affordable to purchase
- Neighborhood electric vehicle (NEV) performance is adequate with existing, affordable, lead acid batteries
- City Electric Vehicle (CEV) battery pack energy storage requirements are only about 1/3 that of a full sized EV, so the latest battery technology can be more affordable.
- Reduced congestion (possible to park 2 NEVs in a single parking space)
- Many niche market applications (station cars, resorts, theme parks, national parks, campuses, planned communities).

4.4.1 Background--Emerging Small EV Classes

Small EVs exhibit a very wide range of capabilities and performance levels. They may be broadly classified as shown on the next page. Similar characteristics for full-range EVs are shown for comparison purposes.

Under current state law and ARB regulation, NEV/LSVs and City EVs all qualify as “passenger cars” and therefore are eligible to earn full ZEV allowances. In terms of trip replacement and the resulting air quality impact, however, it is clear that a NEV, City EV, and a full-range EV differ significantly. ARB staff plan to evaluate the relative emission benefits of the various new categories of vehicles.

Preliminary Staff Assessment--Revised

Vehicle Type	DOT Class	Curb Weight	Energy Storage Capacity	Drive System Peak Power	Maximum Speed	Typical Range	Examples
e-bikes, scooters, motorcycles, etc.	N/A	Varies	0.3- 2.8 kWh	~1kW- ~10 kW	Varies	less than 20 miles	ZAP, ebike, etc.
NEV/ LSV	LSV (Low Speed Vehicle)	950-1400 lbs.	4-9 kWh	~5-15 kW	Less than 25 mph (limited by LSV reqmnts.)	20-30 miles	GEM, Th!nk Neighbor, Bombardier NV, etc.
City EV (CEV)	PC	1800-2500 lbs. typ.	10-15 kWh	~20-30 kW	Typ. less than 62 mph	Typ. 40-80 miles	Toyota e-Com, Nissan HyperMini, Th!nk City, etc
3-Wheeled Enclosed Motorcycle		Varies	3-10 kWh	Varies	28-60 mph	20+ miles	Sparrow
Full-capability EV	PC	3200+ lbs.	15-35+ kWh	50-150 kW	70-80 mph	40-140 miles	EV1, EV-Plus, RAV4 EV, Altra, etc.

4.4.2 City EVs (CEVs)

This emerging class of vehicles is much smaller than most American vehicles and exhibits lower performance than the ICE vehicles currently available on the American market, but they are much more car-like than NEVs. Unlike NEVs, City EVs must meet all existing federal DOT/ FMVSS safety standards for equipment and crash protection. All are equipped with dual air bags, and many offer anti-lock braking systems.

Examples of near-term CEVs include:

Make	Model		Passengers	Curb Weight	Maximum Speed	Range/ Power	Battery Type
Toyota	e-Com		2	1742 lbs.	62 mph	60 miles 19 kW	Panasonic NiMH 288 volts x 28 ahr
Th!nk	City (MY 00)		2	2046 lbs.	54 mph	50 mi 27 kW	Saft NiCad 114 X volts 100 ahr
Th!nk	City (MY 01+)		2	TBD	TBD	TBD	TBD
Nissan	Hyper-mini		2	1852 lbs.	62 mph	60 miles 24 kW	Shin Kobe Lilon
Honda	City-Pal		2	2310 lbs.	68 mph	80 miles	NiMH 288 volts 28 ahr

Auto manufacturers are planning to sell large quantities of CEVs elsewhere in the world, especially in countries where fuel prices are relatively high or gasoline

infrastructure is scarce. Most City EVs fit within the Japanese “microcar” classification limits, which restrict vehicle size to a length of less than 3400 mm (11 feet 2 inches) and a width of less than 1480 mm (4 feet 10 inches). In Japan, there is growing interest in this “microcar” class of for use as second vehicles. Some City EVs whose lengths are less than 2500 mm (8 feet 2 inches) are capable of parking 2-to-a-parking space to help avoid urban congestion. In countries where fuel costs are high, CEVs will be able to provide lower cost of ownership even in the relatively low build quantities expected in the early years of production. They are equipped with battery packs that are approximately one third the capacity (and cost) of those found in full-size, full-performance EVs. City EVs are also expected to demonstrate better operating efficiency than larger EVs and NEVs. All CEVs currently proposed are planning to make use of advanced battery technology (NiMH or Lilon).

Toyota will be providing a fleet of 13 left-hand drive e-Coms for a demonstration program in Irvine, California beginning in February 2000. This program will be run by UC Irvine’s National Fuel Cell Research Center in cooperation with Toyota. The e-Com can charge at either 120 VAC Level I or Level II Inductive charging stations.

The Th!nk City is currently available for lease in Scandinavia. Plans are for 700 units to be imported into the US in 2000, with more than 300 of them coming to California for demonstration programs. Safety features include a driver-side airbag and seat belts with pre-tensioners.

Nissan’s Hypermini is the only NEV or City EV that is presently equipped with Lithium Ion batteries. Safety features include both dual airbags and anti-lock brakes. A Nissan Hypermini station car demo program in Yokohama is scheduled to begin in January 2000, with others to follow. Thirty vehicles are allocated for demonstration in California beginning this year.

4.4.3 Neighborhood Electric Vehicles/ Low Speed Vehicles (NEV/LSVs)

These small EVs have a curb weight of under 1800 lbs., are equipped with speed limiting devices that limit maximum speed to 25 mph, and are restricted to use on roads with posted speed limits of under 35 mph. This vehicle class was legalized on a community basis in California with the passage of AB 110 in 1999. Arizona was the first state to legalize LSVs on a statewide basis. More recently, the National Highway Traffic Safety Administration (NHTSA) defined a new Federal Low-Speed Vehicle class to establish minimum safety and equipment standards for these vehicles (49 CFR Parts 531.3 and 571.500). These regulations define a LSV as “a 4-wheeled vehicle, other than a truck, whose speed attainable in 1.6 km (1 mile) is more than 32 kph (20 mph) and not more than 40 kph (25 mph) on a paved level surface”. Federal requirements do not require LSVs to make use of electric propulsion. The California vehicle code was modified under SB 186 to accommodate this new federal classification, and these vehicles have been legal

for use on public roads statewide since January 2000. An important distinction between Federal and California law is California's additional restriction of unladen weight to 1,800 lbs. or less.

Although these vehicles appear to be similar to golf carts, they offer substantially more performance, better safety features, and are much more road worthy. NEV/LSVs are generally capable of much better acceleration than golf carts and can achieve 25 mph quite rapidly. Golf cart performance is restricted in accordance to cooperative industry standards to 13-15 mph, due to safety and turf maintenance concerns on golf courses. NEV/LSVs are usually equipped with higher-pressure road tires that might damage turf if used on a golf course, and NEVs must also be equipped with much better brakes than would be needed on a golf course. At the present time, all NEV/LSVs on the market are purpose-built designs intended for use as NEVs and are not derivatives of existing golf-cart designs. These improvements also increase the price of a NEV/LSV to more than \$3000, which is more than a typical electric golf cart.

At the present time, NEV/LSVs do not display efficiency labeling, as is required of all other road vehicles. Present EPA test procedures specify that the test vehicles must operate at speeds that are above the capability of LSVs, so the existing test procedure cannot be used to measure the fuel economy or range of these vehicles. Although test information is not yet available for these vehicles, it is believed that their operating efficiency may not be nearly as high as that of City EVs, which are equipped with much more technologically sophisticated componentry. In many cases, it is possible that NEV/LSV operating efficiency may even be poorer than that of full-size and full-capability battery EVs.

Examples of near-term NEVs and LSVs are as follows:

Make	Model	Passengers	Curb Weight	Range/Power	Battery Type
Th!nk	Neighbor	2	950 lbs.	25 mile/ 5 kW	TBD
Th!nk	Neighbor	4	1200 lbs.	25 mile/ 5 kW	TBD
Bombardier	NV	2		30 mile/ 3.7 kW	Sealed lead-acid 72 volt system
GEM	E 825	2+ short bed pickup	980	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system
GEM	E 825	2+ long bed pickup	1200	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system
GEM	E 825-2	2	980	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system
GEM	E 825-4	4	1280	25-30 miles/ 2.6 kW	Flooded Lead-Acid 72 volt system

Deliveries of the Th!nk Neighbor are scheduled to commence in November, 2000. It will be available for sale at selected Ford dealers, via the internet, and at other unspecified outlets, and base price is expected to be approximately \$6000.

Bombardier was the first NEV to apply for ARB certification. The Bombardier vehicles make use of sealed, maintenance-free lead acid batteries, and are available at a base price of \$6,199.

GEM has received certification for its MY 1999 vehicles. Prices vary with model, and range from \$7000 to \$10,000. Unlike some other LSV models, the GEM charging circuitry is designed to be compatible with existing, 120 VAC commercial GFCI-equipped outlets.

GEM NEV/LSVs are the only ones equipped with flooded lead-acid batteries (all others are sealed designs), and will therefore require battery maintenance. GEM recommends checking/ adding battery water to each cell at least once a month.

As noted above, under current state law and ARB regulation, NEV/LSVs qualify as “passenger cars” and therefore are eligible to earn full ZEV allowances. Due to their limited range and functionality, it is apparent that such vehicles will replace far fewer vehicle miles traveled, or trips, than City EVs or full range EVs. Staff thus has significant concerns regarding how such vehicles should be treated for ZEV credit purposes. ARB staff plan to evaluate the use and resulting emission benefits of such vehicles as information becomes available.

5 BATTERY TECHNOLOGY ASSESSMENT

5.1 The Battery Panel

The cost of batteries, both today and when produced in volume, is one of the most critical parameters of this review. To obtain the best available assessment, the ARB has contracted with a team of outside experts. This panel is in the process of meeting with leading battery suppliers and auto manufacturers. Their task is to review the state of the art regarding advanced battery design and manufacturing techniques, and report back to staff regarding likely cost trends for 2003 and beyond. Their draft final report will be presented at the May workshop.

5.2 Range vs. Cost

The current structure of the ARB regulatory and incentive scheme for ZEVs and partial ZEVs is intended to encourage the development of advanced batteries that will allow battery EVs to achieve extended range. For example, additional credit is given in the near term for ZEVs with a range of greater than 100 miles.

This approach has been taken in order to encourage the development of vehicles with sufficient range to cover the majority of trips taken by typical drivers. Such range has been thought to be necessary to achieve mass-market penetration. In addition, the use of advanced batteries has the potential to extend the life of the battery pack compared to conventional lead acid batteries, and thereby reduce the need to replace battery packs during the vehicle life. It has long been assumed that technical advances will reduce the cost of advanced batteries such that in addition to providing extended range, they will be more cost effective than conventional batteries on a life cycle cost basis.

Some parties have argued that the ARB preference for advanced batteries should be revisited. Proponents of this view make the case that the most cost-effective application for battery EVs could be vehicles powered by lead acid batteries, and they question whether the increased range afforded by advanced batteries justifies the extra cost. Others have argued that one appropriate niche for battery EVs could be smaller, shorter-range vehicles for urban and commuter use, and that the ARB incentive structure should not discourage such applications.

Staff believes that the current regulatory structure does not discourage these applications. Instead, it is designed to provide extra encouragement to extended range EVs. Staff is, however, interested in public comment on these issues.

6 INFRASTRUCTURE ASSESSMENT

6.1 Introduction

To achieve zero and near-zero (SULEV) emission levels, together with minimal upstream refueling emissions, the advanced technology vehicles being developed by manufacturers often require the use of fuels other than conventional gasoline. Therefore it will be critical to ensure that the necessary refueling infrastructure is in place to support their widespread introduction.

Recently, the South Coast Air Quality Management District and CALSTART announced an Internet web sit that allows drivers of alternative fuel vehicles to locate refueling stations quickly and easily throughout California. The site covers electric, compressed and liquefied natural gas, propane and methanol fueling facilities. The site will also list ethanol and hydrogen fueling facilities when they become publicly available in California. Clean Car Maps is located at <http://www.cleancarmaps.com>. Users pick an alternative fuel and enter an address and they will receive a map with icons designating the locations of refueling sites in the area. Users can then click on the site name to get comprehensive refueling information from a web database.

6.2 Battery EVs

Public infrastructure enhances the utility of battery electric vehicles. Drivers can extend the length of their trips if they know that convenient recharging facilities will be available at their destination.

The public infrastructure for electric vehicle charging continues to expand in California. Currently, inductive electric charging stations and conductive electric charging stations are available at about 300 and 200 public locations, respectively. The bulk of the locations are in the greater Los Angeles/South Coast area, the San Francisco Bay area, the Sacramento Metropolitan area, and San Diego. In recent years, public infrastructure has expanded to locations in the North Coast, Central Coast, Sacramento Valley and San Joaquin Valley.

The charging facilities at individual locations vary. A grocery location may be equipped with a single electric charging station. A public parking garage is more likely to provide both inductive and conductive charging stations. Major destinations will have a larger number of charging stations. For example, parking Lot 1 at Los Angles International Airport is equipped with ten inductive electric chargers and 6 conductive chargers; there are also plans to place up to 20 inductive and 10 conductive electric charging stations at an additional airport parking lot (Lot 6) that is currently under construction.

ARB staff will continue participating in efforts to expand public infrastructure for electric vehicles. ARB staff has also identified several areas that warrant review in the near term:

- Centralization and maintenance of up-to-date information on public charging station locations and operational status, with dissemination of the information via Internet and annual publication,
- Review and revision, if appropriate, of the criteria for selecting public charging locations to take into account recent increases in electric vehicle range,
- Modification of the public infrastructure to accommodate upgrades to chargers and connectors, and additional electric charging technologies,
- Development of state regulations and local ordinances to discourage parking of internal combustion engine vehicles ("ICEing") at electric vehicle charging stations, and
- Promotion of a courtesy charging protocol to allow more than one user access to a single electric charging station.

6.3 Grid-Connected Hybrid Vehicles

Grid-connected HEVs are generally expected to make use of the same public and private electric charging infrastructure that is currently being installed for battery EVs. One possible difference between battery EVs and PZEV HEVs would be a potential reduction in the demand for higher-power (Level II) charging stations, due to the fact that such HEVs can run on APU power when their battery packs are depleted. It may even be possible for 20 to 40 mile zero-emission range HEVs to make significant use of Level 1 charging (standard 120 VAC), because the smaller battery packs in these HEVs will be able to accumulate useful charge in reasonable time periods with more commonly available Level 1 outlets.

6.4 Fuel Cell Vehicles

In addition to testing vehicles, the California Fuel Cell Partnership (discussed in section 4.2.2.2 above) will also identify fuel infrastructure issues and prepare the California market for this new technology. Initial demonstration vehicles will run on hydrogen, directly from tanks on board the vehicles. Subsequent demonstration vehicles are likely to run on methanol fuel. Technology for other liquid fuels such as a cleaner form of gasoline will be evaluated. A key goal of the Partnership is to determine the best fuel infrastructure for the market entry of fuel cell vehicles.

The Partnership will be devoting considerable attention to fuel cell fuel infrastructure issues. Staff will monitor the Partnership's efforts in this regard and report on status as appropriate.

6.5 Compressed Natural Gas (CNG) Vehicles

There are currently more than 228 CNG vehicle refilling stations in California, of which 104 are available to the public. Most of these are “fast fill” type stations that are capable of refilling CNG vehicles in as little as 2 to 4 minutes.

Although the “fast fill” fuel dispensing infrastructure is relatively sparse, low pressure natural gas is already delivered to most residences in California. Thus manufacturers are working to develop “time fill” devices that would be suitable for home refueling use. These “time fill” devices may take 6-8 hours (overnight) to fill a vehicle, but their availability could make dedicated CNG vehicles a much more viable option for non-fleet users.

7 THE EV MARKET

7.1 Introduction

In this section, ARB staff describes several important components of the EV market--current EV drivers and their experience to date, the manufacturers' marketing strategies, and manufacturers' market analysis efforts to determine potential EV purchasers.

7.2 The EV Driver Experience

The EV driver experience provides important information to manufacturers, regulators and future customers on the utility and viability of EVs in the "real world". Lessons learned with the EVs placed to satisfy MOA obligations can be used to better define the future EV market place by educating potential customers, identifying necessary technology improvements, and identifying desirable EV platforms. Various organizations, including the manufacturers, have surveyed the selected individuals or agencies that have received MOA EVs. The results of past surveys and surveys planned in the near term by groups other than the auto manufacturers are briefly described here.

At this time, ARB staff has only obtained results from one survey that included a significant number of retail customers. While ARB staff are aware of plans to conduct a major statewide survey of EV drivers, the results will not be available for several months. In the meanwhile, ARB staff obtained a preliminary description of the retail customer's "EV Driver Experience", by conducting an informal e-mail survey of EV drivers. Individuals are also invited to submit written testimonials regarding on their EV driving experience to ARB staff. The submittals will be used by staff to provide a composite description of the "EV Driver Experience" for the next draft of this document. The individual submittals will be compiled and provided to the Board.

7.2.1 Retail Customers

Because retail customers were their primary market targets, there is extensive retail customer experience with the GM EV1 and the Honda EV Plus. The GM EV 1 was available for retail leases as early as December 1996. The Honda EV Plus has been available since 1998.

7.2.1.1 August 1998 Electric Vehicle Owner Survey

In mid-1998, the Mobile Source Air Pollution Reduction Review Committee (MSRC), in the South Coast Air Basin, distributed a survey to 284 EV Owners/Lessors taking advantage of the MSRC's buy-down incentive. 106 surveys were returned and 99 surveys were used in tallying the quantitative portions of the survey. All surveys returned were used in the comment portion of

the survey. The majority of the respondents were most likely retail customers, given that 77% of the EVs covered by the surveys received were for the two-seater GM EV1. The average length of ownership was slightly more than 13 months, and the average odometer reading was almost 9,000 miles.

The survey focused on characterizing the EV driver and EV use. 82% of the EV drivers were male. The EV was typically the primary car in a household with more than one vehicle. When asked why they purchased/leased their EV, the top three responses were (1) concern for the environment or a desire to do their part to help clean the air, (2) a desire to be one of the first to adopt an up and coming technology, and (3) the EV's range fit their commute patterns/habits. Based on the survey, the EVs appeared to meet a wide variety of transportation needs:

- Commute to and from work or school (71%)
- Work/business purpose during the work day (63%)
- Shopping, errands during the week (88%)
- Family trips/outings, errands on the weekend (75%)

7.2.1.2 February 2000 Informal Survey Conducted by ARB Staff

There is currently minimal information from independent parties on the retail customer's EV driving experience. To provide information on their EV experience for this preliminary assessment, ARB staff conducted an informal survey of EV drivers via two Internet e-mail groups for EV1 and Honda EV Plus drivers. At this time, staff has received about two dozen responses. Staff will provide a more thorough assessment and updated information in the next draft of this document. A preliminary description of the survey results is included here.

To date, the majority of respondents are GM EV1 drivers, with a few who drive the Honda EV Plus or both vehicles. All of the respondents, both long-term and short-term drivers, rate their overall EV experience as very positive. Almost all of the respondents mention performance, quiet operation, minimal maintenance requirements, convenience of overnight home charging ("a full tank" each morning) and that the vehicles are "fun to drive" as contributing to their overall experience. Those driving EVs using advanced battery technologies, with EV range of 90 miles or greater, perceive a reduced need for public chargers except in strategic locations to allow occasional long distance trips. Respondents mentioned that they had initially expected to need to change their driving habits, but instead found that the EV meets about 95% of their transportation needs. Some respondents remarked on an unmet market demand for 4-seat EV platforms, and their desire for lower vehicle lease/purchase costs.

7.2.1.3 Near-Term Plans for a Statewide Electric Vehicles Users Survey

ARB staff are aware of near-term plans for a comprehensive statewide survey of EV users that will be sponsored jointly by the California Electric Transportation Coalition, the California Energy Commission and the MSRC. The survey is currently in the design stage. Preliminary results are expected at the end of March 2000 and a final assessment by May 2000. A description of the survey results will be provided in the next draft of this document.

7.2.2 Fleet Customers

Fleet customers are those who drive commercial rental EVs or a workplace fleet EV. Fleet customers typically have access to several EV platforms, including 2 or 4 seat passenger cars, trucks, utility vehicles and vans.

7.2.2.1 Air Resources Board Internal User Survey

The ARB Test Fleet, described further in Chapter 6.4.1, makes vehicles available to ARB employees for a period of two days up to a week. From July 1997 to August 1999, 245 employees made more than 2,800 trips with the test fleet. Two popular test fleet vehicles, a Honda EV Plus and a GM EV1, have been driven more than 25,000 miles and 20,000 miles, respectively. The employees were asked to complete a survey regarding their experience with each EV model. Analysis of 141 surveys returned by 99 employees indicates that the respondents typically had a positive to most positive overall experience driving the EVs. About 60% of the respondents indicated that they would consider leasing an EV for personal use. Some respondents identified several factors that they considered as impediments to leasing, including limited range, cost, and the inconvenience of charging. However, ARB staff note that the test fleet user does not typically have access to a charger at home and must share access to chargers at work. ARB staff will provide updated information on the test fleet user experience in the next draft of this document.

7.2.2.2 Office of Fleet Administration Daily Rental Electric Vehicle Survey

The Department of General Services, Office of Fleet Administration operates several State garages that provide daily and long-term vehicle rentals to state agencies. Since July 1997, the State garage in Sacramento has offered free daily rental of the Honda EV Plus and the GM EV1. As of October 1999, more than 525 round trips, averaging 20 miles, have been made with a fleet of five EVs. The EV users were given the opportunity to complete a short survey on their EV driving experience. ARB staff analyzed 70 surveys turned in over a several month period in mid-1999. All of the respondents indicated that they were satisfied with the overall performance of the EV and that the driving range

of the EV met their need (for the rental). Almost 70% indicated that they would consider leasing or buying an EV. The most frequent comment received was that the EV was easy to drive and performed well. Some respondents also mentioned that the range is too limited.

7.2.2.3 Southern California Edison's Municipal Fleet Survey

In 1999, Southern California Edison surveyed a total of 63 municipal agencies, colleges and transit agencies regarding their experience with their EV fleets. These fleets had a total of 178 EVs including the Chevy S10, Ford Ranger, GM EV1, Honda EV Plus, and Toyota RAV4. These agencies also had 67 vehicles in the acquisition process. These vehicles are typically used for administrative, enforcement and inspection purposes or as pool/loaner vehicles. On a per vehicle basis, 84% of those surveyed were satisfied with the operation of the EV. Areas of dissatisfaction included reliability, range and seat/payload capacity. While 96% of the agencies were interested in expanding their EV fleets, the respondents cited the cost (33%) and performance/range (53%) as barriers to greater EV use.

7.2.2.4 Near-Term Plans to Survey Commercial EV Rental Drivers

ARB staff intends to work with EV Rentals, in conjunction with Budget Rent-a-Car, to develop a survey to offer to short-term commercial EV renters at several California airports. ARB staff will describe the survey responses in the next draft of this document.

7.3 Manufacturer Marketing Strategies

In letters dated September 28, 1999, and November 2, 1999, ARB staff requested information on auto manufacturers' marketing activities since the initial ZEV launch. All auto manufacturers responded to the request in a timely manner. ARB staff is currently reviewing the submitted materials and intends to describe each manufacturer's marketing efforts in the next draft of this document, with the understanding that information that the manufacturer has designated as confidential will be handled by ARB staff in an appropriate fashion. ARB staff provides only a general overview of manufacturers' marketing strategies in this preliminary assessment.

The manufacturers offered a variety of EV platforms to the marketplace; however, only GM offered more than one platform. The majority of the manufacturers targeted fleet commercial customers to meet their MOA obligations. Two manufacturers, GM and Honda, targeted retail customers. Table 7-1 below describes each manufacturer's market target groups and its EV platform. The majority offered their EVs through three years leases. Only the lead acid battery version of the Chevy S10 was offered for purchase.

Table7-1
Manufacturers' Market Targets and Vehicle Models

Manufacturer	Primary Market Target and Vehicle Model	
	Retail Customer	Fleet/Commercial Customer
Daimler-Chrysler		Chrysler EPIC (5 seat van)
Ford		Ranger (2 seat truck)
GM	GM EV1 (2 seat car)	
		Chevy S10 (2 seat truck)
Honda	EV Plus (4 seat car)	EV Plus (4 seat car)
Nissan		Altra (4 seat wagon)
Toyota		RAV4 (4 seat sports utility)

The auto manufacturers used a variety of methods to promote public awareness of their EVs and to place their EVs. These methods included:

- Participation in technology and environmental events,
- "Ride and drive" opportunities,
- Advertisements in newspapers and magazines,
- Advertisements on radio and television,
- Product placement in television shows and movies and major cinema releases, and
- Direct mailers.

7.4 Market Analysis

According to the information submitted, some of the manufacturers have sponsored focus groups studies, market analyses, and mass surveys to identify potential EV customers. ARB staff is currently reviewing this material and will provide general descriptions of the results obtained from these various efforts in the next draft of this document.

8 COST INFORMATION (PRELIMINARY)

8.1 Introduction

As noted in the opening discussion of the shared long-term vision, continued reliance on today's technology will not allow us to reach our health based air quality goals. In this vision of the future, the vehicle fleet will produce zero tailpipe emissions, will use fuels with minimal "fuel cycle" emissions, and will be highly energy efficient, with reduced emissions of greenhouse gases.

Thus any discussion of the costs and benefits of ZEV technology must look beyond today's immediate circumstances, and attempt to visualize what is necessary to move towards the desired future. From this perspective, it may be necessary to accommodate short-term losses in order to achieve long term gains.

Automakers have had many years to refine and reduce costs for the manufacture of internal combustion engines. Electric drive vehicles are just at the beginning of the cost reduction cycle. This section presents preliminary information regarding costs for ZEV and partial ZEV vehicles. A more detailed assessment will be provided in the next iteration of this document, taking into account information from the external battery panel, and will be available for review and comment at the May workshop.

8.2 Battery Electric Vehicles

After reviewing several cost models and research (listed in Section 10, References), ARB staff projects that the initial cost of battery electric vehicles in high-volume production will be higher than the conventional vehicle even under the most favorable conditions. This is due to the high cost of the battery pack that overwhelms the possibly slightly lower cost of the rest of the vehicle (in comparison to the conventional vehicle). The projected long term operating costs for an electric vehicle, however, could be comparable to a conventional vehicle due to lower fuel costs (electricity vs. gasoline). While near term operating costs would be higher for an electric vehicle, continuous development and increased production volume building, along with lower fuel cost, could ultimately offset higher total battery cost.

8.3 Fuel Cell Vehicles

As indicated above, cost is also the major issue facing the development of fuel cell vehicles. While these systems are currently extremely expensive, efforts are ongoing to meet stringent cost goals for every material, component and manufacturing process. Ultimately, the use of automated manufacturing will be necessary for all components and subsystems if these stringent cost goals are to be met. To date, automakers have not yet encountered any fundamental barriers to meeting these cost goals.

8.4 Partial ZEV Vehicles

Although Partial ZEV vehicles at present also face a cost penalty, that penalty is relatively minor and is expected to be further reduced as production levels are increased. Hybrid vehicles, with two propulsion systems, will be more expensive to produce than PZEV certified conventional ICE vehicles. Due to their increased efficiency, hybrid vehicles will recover at least a portion of this cost penalty via reduced fuel cost, as will battery EVs and fuel cell vehicles.

8.5 Infrastructure

Infrastructure for battery electric vehicles is reasonably widespread and there are no technical barriers to further expansion of the network. The current cost of the charging equipment is around \$2,000, but is expected to decline as volume increases. Installation cost varies by site and can range from minimal added cost up to \$5,000 or more per site.

From the overall system demand standpoint, at market penetration levels expected under the ARB regulation electric vehicles do not increase on-peak energy or capacity requirements in California.

As noted above, infrastructure issues related to fuel cell vehicles are being investigated by the California Fuel Cell Partnership, and will be discussed in more detail at a future date.

9 EMISSION BENEFIT INFORMATION (PRELIMINARY)

9.1 Introduction

This section provides preliminary information on emissions from battery electric vehicles and fuel cell vehicles. The Air Resources Board and the California Energy Commission currently have staff analyses and contract studies underway that will update and refine these estimates. These comparisons do not at present include “upstream” emissions from conventional vehicles due to fuel production and transfer, and vehicle refueling. Such estimates, which are also being updated in a contract study, will be included in the next iteration of this document.

These discussions also do not include any consideration of air toxic emissions. The benefits of reductions in toxic air contaminants are felt statewide. Recognizing that mobile source pollution may disproportionately affect inner city and low-income neighborhoods, however, reductions in toxic emissions from motor vehicles also can help address community level public health concerns. The ARB is preparing a draft plan to address neighborhood impacts of air pollution sources. To the extent possible, a comparative analysis of toxic air contaminant emissions will be included in the next iteration of this document.

9.2 Per Vehicle Emissions--Battery Electric Vehicles

In 1995, the ARB staff worked with the California Energy Commission and interested stakeholders to determine the emissions impacts from the use of battery electric vehicles in California. To provide an “apples-to-apples” comparison of several different fuels and vehicle technologies, the study focused on the marginal emissions that occur in the South Coast Air Basin, or greater Los Angeles area. (Marginal emissions are the incremental emissions that are produced due to the operation of an additional vehicle.)

The results of the CEC’s analysis showed that power plant emissions from the use of battery electric vehicles in the South Coast Air Basin in 2010 range from 0.008 to 0.012 grams of NO_x per mile. Marginal HC emissions from electric vehicles based on the CEC study would be less than 0.005 grams per mile in 2010. At the time, these emissions were essentially an order of magnitude lower than the cleanest certification standard required by the ARB. In 1998, however, the ARB adopted a new standard, the Super Ultra Low Emission Vehicle standard that is comparable to estimated power plant emissions from battery electric vehicles.

The study also quantified global greenhouse gas emissions that would result from the use of battery electric vehicles in the South Coast. While the overall efficiency of a battery electric vehicle is comparable to that of a conventional vehicle, total carbon dioxide emissions are reduced by over 50 percent when

compared to gasoline vehicles due to the varied sources (e.g. wind, solar, hydro, nuclear, natural gas) of electricity production in California.

In early 1999, the CEC provided an update to the work done in 1995 to account for the major changes occurring as a result of de-regulation in power generation. The results from this study show that the incremental emissions will be similar to the emissions projected in the Energy Commission's 1995 EV Report. The primary difference noted is in the mix of incremental energy imported from areas outside of California. The majority of imported energy to meet the slight increase in off-peak demand is now expected to be from gas-fired power plants. The 1995 study projected a constant mix of gas, hydro and coal-fired generation from imported energy. Under either scenario, the total emissions that will occur in the South Coast Air Basin are projected to be extremely low.

9.3 Per Vehicle Emissions--Fuel Cell Vehicles

As with battery electric vehicles, fuel cell vehicles will result in the emissions of pollutants at stationary sources producing the hydrogen. In 1996, ARB contracted with Acurex (now Arthur D. Little) to assess the full fuel-cycle emissions from several different fuels and technologies. The study focused on the environmental impacts in the South Coast Air Basin from each fuel. In the case of hydrogen, many different methods for hydrogen production were discussed. These include methane reformation, oxidation of oils, coal gasification and electrolysis. For purposes of estimating total emissions in the South Coast Air Basin, the report assumed that hydrogen would be produced from natural gas and biomass.

The results of the analysis demonstrate that the overall marginal fuel cycle emissions in the South Coast Air Basin from producing and distributing hydrogen to fuel cell vehicles would be 0.0015 grams NO_x and 0.0005 grams HC per mile of vehicle operation. These estimates are much less than the lowest emission standard (SULEV) and provide the most important reason for the ARB's interest in the technology. As for greenhouse gas emissions, the good overall efficiency of the fuel cell vehicle is expected to provide a positive impact on carbon dioxide and other global greenhouse gas emissions.

9.4 Emission Inventory Analysis

To assess and update the emissions benefits of the ZEV program, ARB staff will conduct a thorough emissions impact analysis, using the updated on-road emissions inventory model. The model, EMFAC2000, is scheduled for Board review and approval on March 23, 2000. Once the model is approved, ARB staff will prepare an emission impact assessment. The updated assessment will be incorporated into the next iteration of this document and will be on the agenda for public comment at the May 31, 2000 workshop.

10 CONCLUSION

The ARB is committed to working closely with all interested parties to ensure that they have an opportunity to provide comments and suggestions throughout the review process. The key milestones of the review process are as follows:

March 29, 2000	Public Workshop Background Information for the September Review Sacramento
March 30, 2000	Public Workshop Multi-Manufacturer Ownership Arrangements Sacramento
May 31, 2000	Public Workshop Background Information for the September Review El Monte
July 2000	Staff Report released to the public
September 7, 2000	Board Meeting

Comments are welcome on all aspects of this material. Following the March public workshop and the review of all comments received, staff will make changes as appropriate and release a preliminary draft of the Staff Report and the accompanying Technical Support Document prior to the May workshop. After discussion at the May workshop and the consideration of all comments received, staff will release the final Staff Report and Technical Support Document in July.

By following this process we hope to provide a firm, agreed-upon technical basis for the Board's policy review and discussion at the September Board meeting.

11 REFERENCES

Publicly Available Reports:

Montano, M., S. Unnasch, and P. Franklin, *Reclamation of Automotive Batteries: Assessment of Health Impacts and Recycling Technology*, prepared by ARCADIS Geraghty & Miller for the California Air Resources Board, April 1999

Vyas, et al., *Electric and Hybrid Electric Vehicles: A Technology Assessment Based on a Two-Stage Delphi Study*, ANL/ESD-36, Argonne National Laboratory, U.S. Department of Energy, Argonne, December (1997)

Vyas, A., R. Cuenca, and L. Gaines, 1998, *An Assessment of Electric Vehicle Life Cycle Costs to Consumers*, Proceedings of the 1998 Total Life Cycle Conference, SAE International Report, Warrendale, PA.

Confidential Submittals from Auto Manufacturers:

Product Plans

1999 MOA Product Plan Report, DaimlerChrysler Corporation, October 29, 1999

ZEV Product Plan, Ford Motor Company, October 4, 1999

MOA Status Report Related To Zero Emission Vehicle Product Plans, General Motors, November 1, 1999

Second Biennial ZEV Product Planning Report, American Honda Motor Company, October 27, 1999

MOA 1999 Zero Emission Vehicle Product Plan, Mazda Motor Corporation, October 26, 1999

Nissan 1999 Zero Emission Vehicle Product Plan, Nissan North America, Inc., November 1, 1999

Toyota ZEV Product Plan, Toyota Technical Center USA, October 29, 1999

Summaries of Marketing Efforts and Approach

DaimlerChrysler ZEV Marketing Efforts, DaimlerChrysler Corporation, October 28, 1999

Preliminary Staff Assessment--Revised

Ford Ranger EV Sales and Marketing Report, Ford Motor Company, November 16, 1999

General Motors Corporation Zero Emission Vehicle (ZEV) Marketing Activities Report to the California Air Resources Board, General Motors, November 22, 1999

Honda EV Plus Marketing Plan and Implementation: A Special Report to the California Air Resources Board, American Honda Motor Company, November 15, 1999

Nissan Altra EV Marketing Activities, Nissan Research and Development, November 12, 1999

Toyota Marketing Strategy for Advanced Battery EVs, Toyota Technical Center USA, November 24, 1999

1998 Annual MOA Reports

1998 MOA Annual Report, DaimlerChrysler Corporation, March 29, 1999

1998 Calendar Year MOA Annual Report, Ford Motor Company, March 26, 1999

1998 Calendar Year MOA Report, General Motors, March 29, 1999

1998 ZEV Annual Report to CARB, American Honda Motor Company, March 30, 1999

MOA 1998 Calendar Year Annual Report, Mazda Motor Corporation, March 25, 1999

Zero Emission Vehicle Annual Report for 1998, Nissan Research and Development, March 2, 1999

1998 Calendar Year Annual MOA Report, Toyota Technical Center USA, March 29, 1999